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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

S·A·E

NOVEMBER 1917

FORMERLY THE S.A.E. BULLETIN

SOCIETY OF AUTOMOTIVE ENGINEERS INC.
29 WEST 39TH STREET NEW YORK

BIJUR ON THE JOB

They Find the Truth About Non-Gran and Adopt It

THE Bijur Motor Lighting Company, manufacturers of the "Bijur System" for electric lighting and starting, are not content, nor have they ever been content, to stand still.

With "Bijur" it is always test—test—test. And when Bijur makes a test they do it right. They don't test one or two samples for one or two weeks. They test hundreds of samples and test for months.

Because of their "Never stand still" and "Forge ahead" policy, "Just good" was not good enough for the main bearings supporting the armature of the Bijur Generator. In their search for complete adequacy and uniformity, in these vital bearing parts, Non-Gran Bronze was naturally among the many metals tested. Hundreds of Non-Gran castings were put through the ropes.

Of course Non-Gran proved its superior adequacy and superior uniformity. When put to actual service test Non-Gran **always** proves its superiority.

If it's a "Bijur" you can bet on its bearings.

AMERICAN BRONZE CORPORATION

Berwyn **Pennsylvania**

HIGH SPEED

NON-GRAN

BEARING BRONZE

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. I November, 1917 No. 5

Relation of

THE JOURNAL OF THE SOCIETY TO THE MEMBERS

LAST spring when it was determined to supersede the old S. A. E. BULLETIN by a new publication, it was difficult to predict just what THE JOURNAL could be to the members and just how it could function in its capacity as the monthly publication of the Society.

As far as stature goes, there was no period of childhood for THE JOURNAL, the very first issue having reached a height that every succeeding one has found it difficult to excel. Nevertheless, an effort is being made in each issue to give the members of the Society a technical periodical of merit, one of service to them in carrying on their daily work and one of which they can justly be proud.

The war activities of the Society in themselves furnish an immense amount of information that should be made known to the members. Add to this the manifold activities of other public organizations engaged in automotive war work, and it can readily be appreciated that the possibilities are almost infinite.

The military services, Government bureaus, advisory committees of an official nature—all these are doing work of the greatest importance to automotive engineers. The article in this issue, describing the National Advisory Committee for Aeronautics, is a good example of the spirit in which THE JOURNAL is striving to serve S. A. E. members. Another example is the articles dealing with the design of military trucks, an activity in which a large number of S. A. E. members have taken a prominent part. This subject is brought up to date elsewhere in this issue, a general description being given of the Class A war-truck and a brief account being presented of the preliminary work now under way on the new Class AA war-truck.

The best service of THE JOURNAL to the members is really the best service it can render the Government. Consequently the monthly periodical of the Society is doubly useful. First to the Government in obtaining the co-operation of Society members in respect to its automotive engineering program. This is being accomplished in part by the activities of General Manager Coker F. Clarkson, who is spending all his time in Washington, and to a considerable degree by the articles appearing regularly in THE JOURNAL. These articles are written specially from the Society viewpoint and are designed to tell what automotive engineers are doing in Washington and elsewhere for the nation. The secrecy required by reasons of military policy must, of course, be observed in all such articles, but much information should and can be made available to automotive engineers by means of THE JOURNAL.

Secondly, THE JOURNAL is of service to individual Society members, who are patriotically interested in Government engineering activities, and who are entitled to know the part the Society and other bodies working along automotive lines are taking in the war. Many members, of course, have business interests that make valuable to them the authoritative information to be found in THE JOURNAL.

Many subjects under consideration by the Standards Committee of the Society are of the utmost importance in connection with the prosecution of the war. Aeronautic standardization especially is receiving a great amount of consideration. Each month THE JOURNAL gives the members a general survey of the recommendations made by the Aeronautic Division. In addition, other important work is carefully followed. The Motorcycle, Lighting, Miscellaneous, Tractor and other Divisions are at work, and their actions are recorded.

The eight Sections of the Society are holding meetings regularly in spite of the fact that many members have entered the Government service, and are therefore unable to take any part in the Section work. The details of the Section activities are given in each issue of THE JOURNAL, as are also a number of the technical papers presented. In this issue, for instance, are printed important papers delivered before the Buffalo and Detroit Sections. Mr. Burkhardt's paper on crankshaft design should interest a large number of members. The Detroit Section paper, dealing with laboratory testing and emphasizing the needs of standardizing the methods of doing such work, will also be found in this number.

The news features contained in THE JOURNAL should be carefully followed by the members. Reports are given of the important actions taken at each meeting of the Council. Any actions of special committees are described so that the members can be fully informed regarding all Society activities. The directory of S. A. E. members in the service of the nation is valuable for a number of reasons, and is kept up-to-date as much as possible in view of the rapid changes that are taking place. The membership matters covered in THE JOURNAL should receive careful consideration, this referring especially to the applications for admission to the Society. All the members should read these over carefully and send any germane information regarding applicants to the New York office for transmission to the Council.

The advertising section of THE JOURNAL is increasing both in diversity of interest and in its service to the members. A new section has recently been added to include professional cards of members, thus showing where consulting service is available. It will be noticed also that a large amount of technical information regarding the parts, material and equipment going into automotive apparatus is contained in the advertising section.

Aeronautic Advisers of the Nation

EDITORIAL CORRESPONDENCE *Illustrated with* PHOTOGRAPHS

ON THE fifth floor of the Munsey Building, Washington, in a modest suite of offices, are the headquarters of one of the important factors in the development of the American aircraft industry. What is officially known as the National Advisory Committee for Aeronautics has been in existence for nearly three years, and in that time has rendered advice of great value on scientific and industrial problems. Quietly and steadily, without ostentation, but with the dignity befitting the seriousness of its mission and the eminence of its members, the Committee has carried on its work in promoting the arts and sciences related to aeronautics.

Several years before the war started it was considered desirable in England to establish a similar organization. Prior to 1914 the investigations of the British Advisory Committee were given freely to the world, and were distinguished for their scientific merit as well as for their usefulness in promoting the industry. Since the war started, of course, it has not been possible to give out the results of the British research work, although it has been conducted with ever-increasing vigor and with full recognition of the importance of having a body to which technical problems could be referred, leaving the actual production and operation to other organizations.

Creation of Committee

Three years ago the need for a similar aeronautic body was felt in this country, and Congress passed a law creating an Advisory Committee for Aeronautics, "to consist of two members from the War Department, from the office in charge of military aeronautics; two members from the Navy Department, from the office in charge of naval aeronautics; a representative each of the Smithsonian Institution, of the United States Weather Bureau, and of the United States Bureau of Standards; together with not more than five additional persons who shall be acquainted with the needs of aeronautical science, either civil or military, or skilled in aeronautical engineering or its allied sciences."

The law provides that the Committee report to the Congress through the President, and that its duty is "to supervise and direct the scientific study of the problems of flight with a view to their practical solution, to determine the problems which should be experimentally attacked, and to discuss their solution and their application to practical questions. In the event of a laboratory or laboratories, either in whole or in part, being placed under the direction of the committee, the committee may direct and conduct research and experiment in aeronautics in such laboratory or laboratories."

The officers and members of the Committee are as follows:

Dr. William F. Durand, chairman, Stanford University, California.

Dr. S. W. Stratton, secretary, Bureau of Standards.

Dr. Charles D. Walcott, chairman Executive Committee, Smithsonian Institution.

Dr. Joseph S. Ames, Johns Hopkins University, Baltimore, Md.

Lieut. Col. V. E. Clark, U. S. A., Aviation Section, War Department.

Dr. John F. Hayford, Northwestern University, Evanston, Ill.

Prof. Charles F. Marvin, U. S. Weather Bureau.

Hon. Byron R. Newton, Treasury Department.

Dr. Michael I. Pupin, Columbia University, New York.

Major General Geo. O. Squier, Chief Signal Officer, U. S. A.

Rear Admiral D. W. Taylor, Chief Constructor, U. S. N., Navy Department.

Lieut. Comdr. J. H. Towers, U. S. N., Navy Department.

The rules of the committee, as approved by the President, provide that it shalll exercise its functions for the military and civil departments of the Government and also for private parties.

While the committee, as a whole, holds only two regular meetings a year, its work is carried forward continuously by the Executive Committee, which is elected annually, and by various subcommittees organized under the Executive Committee. The chairman of each of these is a member of the Committee itself, while the other members are fitted specially for the work in hand. These subcommittees are in constant communication, either by letter or by meetings, in regard to the subjects assigned them.

Details of Organization

The work of the subcommittees is supervised and correlated by the Executive Committee, composed of seven members of the main Advisory Committee, and meeting, as a rule, two or three times a month. This Executive Committee has broad powers to act in the periods between meetings of the Advisory Committee, and can thus carry on the work efficiently.

There is necessarily an immense amount of correspondence and detail work resulting from the committee's relations with the Government, the aeronautic industry, and with the public. (In fact, these three divisions can well, and will be, followed in considering the Committee's activities.) A good-sized office staff is therefore maintained at Washington, this consisting of scientists, engineers and clerical assistance needed to facilitate the transaction of the business in which the Committee is engaged.

It has previously been implied that the activities of the committee can be considered under the heading the Government, the industries and the public. The Army and Navy are interested as the principal purchasers, and in addition the Bureau of Standards and the Weather

Photographs from Harris & Ewing
DR. WILLIAM F. DURAND DR. CHARLES D. WALCOTT DR. S. W. STRATTON

Bureau can render scientific assistance. The Committee also is in close touch with the work of such official advisory bodies as the Council of National Defense and the Naval Consulting Board. The activities of the Committee are thus of service in uniting the Army and Navy in things common to them in the field of experimental and practical aviation. The result is a saving in money, a prevention of duplication of effort, and an increase in the speed and efficiency with which the work of the military services is conducted. Equally important is the way in which the Committee has been successful in coordinating the aviation activities of the military service with those of the Government Bureaus, whose cooperation is essential to the development of practical aviation. Examples of this are the meteorological work being done for the Committee by the Weather Bureau, and the development of materials, the investigations of fundamental scientific problems, and the testing of aeronautic instruments, all of which are being conducted at the Bureau of Standards.

Stimulation of Industry

The relation of the Committee to the aeronautic industries is mainly that of stimulating the manufacturers interested in the production of materials, equipment and accessories. This is accomplished by placing before the manufacturers, present or prospective, proper information as to requirements; also by bringing about healthful competition in all such construction and by making our industrial facilities more quickly available for satisfying the needs of the nation. By far the most far-reaching service of the Committee has been the cooperation it has secured among manufacturers. This has consisted in first organizing the aeronautic industry into an association; second, cleaning up the patent situation in regard to aeronautics; and third, getting the industry into line to provide for quantity production of aircraft.

Negotiations started by the Committee in January, 1917, at the request of the War and Navy Departments, have led to the Committee recommending a form of agreement for cross licensing aeronautic patents between manufacturers. This agreement is now in successful operation; besides encouraging construction to the highest degree, it has opened the industry to free competition, with resultant benefit to all. The Committee, in April of this year, recommended to the Council of National Defense that an Aircraft Production Board be appointed to consider problems arising in connection with the production of aircraft and the training of aviators. The Aircraft Production Board was appointed, with Howard E. Coffin as chairman, and did an immense amount of work in its capacity as an advisory body. An Act of Congress has recently established an Aircraft Board, and given it clearly-defined duties, but the credit for initially suggesting it belongs to the Committee.

Work with Inventors

It is greatly to the interest of the nation that the public be encouraged to give the utmost support to the aviation program. The Committee has assisted in this by acting as a clearing house for suggestions intended to improve the construction of aircraft, or of essential materials and parts. All such suggestions are carefully considered, and, when deemed of value, are tried out or passed on to the Government office most vitally interested. This activity of the Committee has been found of immense value to the military services, and has eliminated much useless experimental work with inventions scientifically unsound.

The Committee has encouraged research work by many investigators connected with university and other laboratories. The application of the results of scientific research to practical aviation has thus been expedited. By making known the needs of the industry and suggesting specific problems to private investigators the Committee has prevented much unnecessary waste of energy and duplication of effort.

A matter of public interest is the recommendation made in December, 1916, that the metric system be adopted for all aeronautic drawings and calculations. On account of production difficulties it has not been possible to follow this recommendation completely, but a step toward it has been made by the use of metric equivalents with dimensions given in English units.

A great amount of work is now being done by the subcommittees of the Executive Committee of the National Advisory Committee. Much of this cannot be described, for military reasons, but a brief outline may be of interest.

Members of the Subcommittees

The personnel of these subcommittees follows:

Aerial Mail Service: Messrs. Squier (chairman), Marvin, Stratton, Towers, and Clark.

Aero Torpedoes: Messrs. Towers (chairman) and Clark.

Aircraft Communications: Messrs. Pupin (chairman), Ames, Stratton, and Rosa.

Airplane Mapping: Messrs. Squier (chairman), Walcott, Bagley, and Fisher.

Bibliography of Aeronautics: Messrs. Marvin (chairman) and Ames.

Buildings, Laboratories and Equipment: Messrs. Stratton (chairman), Ames, Durand, Clark, and Towers.

Design, Construction and Navigation: Messrs. Squier (chairman), Ames, Towers, Clark, Zahm (secretary), Alger, and Hersey.

Aeronautic Instruments: Messrs. Ames (chairman), Jewell, Hersey, Mendenhall, and Briggs.

Editorial: Messrs. Ames (chairman), Stratton and Durand.

Foreign Representatives: Messrs. Walcott (chairman), Squier, and Taylor.

Governmental Relations: Messrs. Walcott (chairman), and Stratton.

Helicopter, or Direct-Lift Aircraft: Messrs. Durand (chairman), Pupin, Sellers, Wilson, and Zahm.

Nomenclature for Aeronautics: Messrs. Ames (chairman), Stratton, Squier, Bristol, and Richardson.

Power Plants: Messrs. Stratton (chairman), Squier, Durand, Towers, Dickinson (secretary), Riley, Newcomb, and Atkins.

Quarters: Messrs. Stratton (chairman) and Squier.

Relation of the Atmosphere to Aeronautics: Messrs. Marvin (chairman), Ames, Hayford, Towers, Milling, Humphreys, and Blair.

Special Committee on Engineering Problems: Messrs. Durand (chairman), Stratton, Zahm, Dickinson, Chase and Loening.

Standardization and Investigation of Materials: Messrs. Stratton (chairman), Ames, Squier, Durand, Hayford, Hunsacker, Nelson, and Walen.

Special Committee Activities

The subcommittee on aerial mail service has suggested to the Post Office Department of the Government that experimental routes be inaugurated under conditions as favorable as possible. For example, it was suggested that routes between Washington and Philadelphia, or between Washington and New York, be established. This work has been suspended since the war started because of the shortage of aircraft for other than military purposes, and because the Committee is now devoting all its energies to the war needs of the nation. It is also proposed that Congress authorize that machines unsuitable for military service be utilized for mail.

The subcommittee on aerial torpedoes has considered a number of designs and the possible use of such devices. Plans are now under way for perfecting them.

The main problems in aircraft communication, as set forth by the subcommittee on the subject, are the development of a satisfactory sending generator for wireless, a vacuum-tube oscillator for telephonic communication, and a means for receiving messages. Satisfactory solutions of these problems have been found by the subcommittee in cooperation with industrial organizations. A wind-driven, high-potential, direct-current generator for feeding the oscillator has been developed, and progress has been made in developing a method for detecting and locating invisible aircraft.

Mapping Camera Developed

The subcommittee on airplane mapping was confronted with the necessity of finding a method at once accurate, economical and rapid of mapping the territory passed over by aircraft. The result has been the development of an entirely new aircraft mapping camera, with which an area in width more than three times the height of the camera from the ground can be taken. It has been found necessary to make two distinct types, one for flat and another for rough ground. A system of preparation and of marking for routes has also been devised.

A complete bibliography on aeronautic titles covering the period from 1909 to 1916 is being prepared, and is already completed up to the beginning of the war. Owing to the disturbed condition of aeronautic literature it is not intended at present to bring the bibliography up to date.

The special committee on engineering problems was established through the recommendation of the War and Navy Departments that the Committee, because of its highly-trained technical staff, with specialists in the science of the mechanics and aerodynamics of aerial navigation, investigate and consider the various aeronautic suggestions and inventions that come to the departments from all parts of the country in response to the national emergency. Accordingly, the Committee has acted as a board of inventions for these departments of the Government. Since the outbreak of hostilities between the United States and Germany it has weekly examined hundreds of suggestions and inventions pertaining to aeronautics, referred to the Committee by the War and Navy Departments, and also those suggestions and inventions that come direct. This work has necessitated several of the members of the Committee giving their time unsparingly to the consideration of inventions and the conduct of the necessary correspondence with the inventors. This has also involved a great increase in the general office work of the Committee. Several suggestions of value have been received and brought promptly to the attention of the particular Government offices most vitally interested.

Selecting Site for Aviation Field

The act creating the Advisory Committee gave it power to conduct research work in aeronautics in laboratories placed under its direction. In the fall of 1916 a subcommittee was appointed to help select a site for a combined aviation, experimental and proving grounds for the Army, Navy, and for the Advisory Committee itself. The thoroughness with which this problem was solved is characteristic of all the Committee's activities.

First, a statement was prepared showing the requirements for such a ground. For instance, it was considered essential to have it within easy access of New York, Philadelphia, and other industrial centers of the country; to locate it as near Washington as possible because of the aircraft personnel having headquarters there; to have it near the sea, so as to be suitable for the testing of seaplanes and yet well protected from enemy attack; and finally to select a site with proper physical characteristics and in a healthful location.

With these requirements in mind, several proposed sites were visited, and finally one near Hampton, Va., was recommended. This site has been acquired by the Government, and named Langley Field. The construction work on the field is now going forward. The Committee is planning for a research laboratory, wind tunnels, and engine-test shed, and installing equipment to handle experimental engine testing, wind-tunnel testing of model planes and propellers, and tests on full-size machines. The research laboratory building now under construction will contain apparatus for structural testing, a chemical laboratory, photographic laboratory, drafting room, machine and pattern shops, and administrative office.

Tests at High Altitude Conditions

A low-pressure testing laboratory has been installed by the subcommittee on power plants at the Bureau of Standards, so that tests of engines under actual service conditions can be made. Particular attention will be paid to the study of spark-plug, carburetion and ignition problems. The wind tunnel will be of the Eiffel type, with the operators in an air-lock with the measuring instruments. The air speed will be such that tests can be made at velocities up to 150 m.p.h.

The model tests made in the wind tunnel will be checked with tests on full-size machines. Special apparatus is now being designed for measuring in actual flight propeller thrust, wing resistance, and other performance factors.

The subcommittee on design, construction and navigation is developing an entirely new type of geographic position indicator for use on aircraft. It has had prepared a report to be issued in the near future on the relation of horizontal tail surface to stability. Other important activities have been the experiments looking to the development of a muffler for airplane engines and the making of a logical series of propeller tests, the results of which will soon be published.

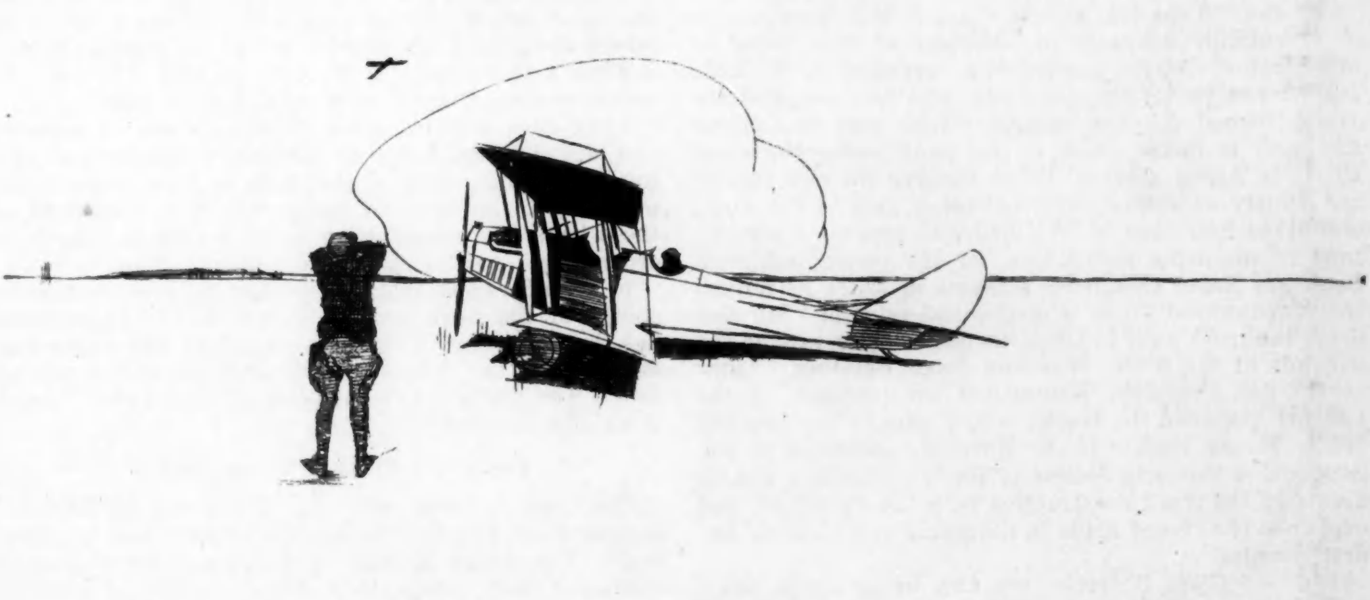
The subcommittee on governmental relations handled the work relating to aeronautic patents at its inception. Later a special subcommittee on patents was created, which completed the negotiations. The subcommittee on governmental relations investigated the question of insurance for aviators, and after conferring with insurance companies recommended that the Government assume part of the load, so that the cost of the insurance would not be unduly burdensome to the aviator. This subcommittee also worked out with the U. S. Weather Bureau plans for securing more comprehensive observations in free air. As a result, Congress granted $100,000 to the Weather Bureau for the purpose of extending its aerological work in aid of aviation. A number of new stations for doing this work are now in operation.

The nomenclature of aeronautic terms prepared and issued by the Committee has come into general use in this country.

The subcommittee on power plants has been very active, particularly in regard to investigations conducted by it at the Bureau of Standards, under the supervision of Dr. H. C. Dickinson, the secretary. It is probable that reports from this committee on the following subjects will be published in the third annual report of the committee: Design of aircraft radiators; aircraft engine performance, as affected by altitude; some effects of fuel and carburetion on engine performance; progress report on spark-plug investigations; and preliminary report on vapor pressures and latent heats of fuels.

After-the-War Possibilities

The Advisory Committee is not a war organization, although from the very nature of its work it is rendering a service of the greatest importance in carrying on the war. The foregoing paragraphs have shown many ways in which the work of the Committee will be useful in times of peace. The development of commercial aeronautics is a task that will engage its best efforts for many years to come. Since the present activities will naturally form a ground work for the future, the after-the-war functions of the committee will unquestionably transcend those now being carried on, as regards both their usefulness to the nation and their service to humanity. Thus in every way the work of the Committee is deserving of the heartiest support of the nation to whose interest it is devoted.



Class B War Trucks at the White House Ready for Inspection by the President

Details of New War Trucks

EDITORIAL CORRESPONDENCE *Illustrated with* PHOTOGRAPHS

AS WAS noted in the last issue of the JOURNAL, on Oct. 19 the two sample Class B War Trucks were officially delivered to Secretary of War Baker at Washington. At the presentation ceremony A. W. Copland, representing the engineers who had designed the truck, turned the two sample trucks over to General Chauncey B. Baker, officer in charge of transportation of the U. S. Army. General Baker thanked the members of the Society and others who had taken part in the work, and asked Secretary of War Baker to express the gratitude of the army and nation for the results achieved. Secretary Baker then made a speech in which he termed the standardized truck a mechanical triumph. He also drove the truck built in Ohio, his native state, around the grounds of the State, War and Navy Building. Later in the day President Wilson and the members of the Cabinet inspected the trucks, which were driven into the White House Park. H. L. Horning, chairman of the Automotive Products Section of the War Industry Board, discussed the truck construction with the President, and explained the record made in designing and building the first samples.

The two Class B trucks are now being tested daily under the supervision of H. F. Thomson, formerly of the Massachusetts Institute of Technology. It has been found that the trucks will operate satisfactorily under the most severe service conditions, on heavy clay hills where the ground has caved in under the wheels, through a ditch 4 ft. deep and 7 ft. wide, and up a 19 per cent grade on second speed carrying full rated load.

Long runs are now being made each day in order to test out different types of fenders, magnetos and carbureters. Only very slight changes have been found necessary in the original design, the most important of these being the substitution of 40 for 36-in. wheels in order to get greater speed and better traction.

It is understood that the production organization in charge of the work for the Quartermaster Department has the first order of the Class B trucks well under way and expects the deliveries will start early the coming year. The problem now, however, is to get the Class A truck into production.

Design of Class A Truck Settled

The Class A truck will carry a pay-load of 3000 lb., according to the Quartermaster Department specifications. The design actually worked out, however, can be compared most closely to a 2-ton commercial product. The work was started in the middle of October, and in thirty-five days afterward the assembly and detail draw-

GROUP OF OFFICIALS OF THE WAR DEPARTMENT, OFFICERS OF THE QUARTERMASTER CORPS, MEMBERS OF THE SOCIETY
STATE, WAR AND NAVY BUILDING, IMMEDIATEL

1. R. J. Koefoed
2. C. W. Gildea
3. Mr. McIntyre
4. F. E. Mennen
5. A. F. Milbrath
6. C. H. Boone
7. A. Krause
8. R. J. Barrows
9. S. O. White
10. Fred Engel
11. G. W. Carlson
12. G. C. Carhart
13. E. B. Flanigan
14. Mr. Mossburgher
15. F. Kohlberger
16. C. A. Miller
17. J. H. Sunderlin
18. E. E. Wemp
19. R. W. Austin
20. J. B. Fisher
21. Captain Bitterman
22. H. D. Rapp
23. J. J. Boglarsky
24. Lieutenant Yearling
25. Lieutenant Matlack
26. W. J. Quinn
27. W. D. Rockwell
28. F. T. Patterson
29. G. McCombe
30. R. Brown
31. A. J. Wilson
32. W. L. Church
33. H. J. Agins
34. H. W. Evans
35. F. C. Booth
36. C. L. Savage
37. C. Tazelaar
38. F. F. Kishline
39. A. W. Lieberman
40. G. B. Ingersol

PS, MEMBERS OF THE SOCIETY AND OTHER ENGINEERS, AND ENGINEERING DRAFTSMEN; ALL OF WHOM TOOK PART IN THE DESIGN OF
NAVY BUILDING, IMMEDIATELY FOLLOWING THE CEREMONIES AT WHICH SECRETARY OF WAR BAKER (NO. 67) RECEIVED THE FIRST CLAS

33. H. J. Agins
34. H. W. Evans
35. F. C. Booth
36. C. L. Savage
37. C. Tazelaar
38. F. F. Kishline
39. A. W. Lieberman
40. G. B. Ingersol
41. G. D. Brimble
42. Lieutenant Lampkin
43. A. E. Parsons
44. W. C. Lipe
45. Alex. T. Brown
46. H. J. Garceau
47. P. W. Smith
48. A. C. Kiedel
49. W. R. Vohrer
50. W. N. Osborn
51. C. W. Spicer
52. S. H. Woods
53. A. Janson
54. L. L. Russell
55. L. W. Dresser
56. A. W. Copland
57. Capt. Matthew Farrell
58. C. E. Heckel
59. Major Edward Orton, Jr.
60. F. C. Kroeger
61. Capt. Wm. M. Britton
62. A. L. Hopkins
63. E. L. Bare
64. Christian Girl
65. Co
66. A
67. Sec
68. J. C
69. Ma
70. Qu
71. R.
72. H.

ESIGN OF THE CLASS B UNITED STATES MILITARY TRUCK. TAKEN OCT. 19, IN WASHINGTON, IN THE PARK OF THE
IRST CLASS B TRUCKS ON BEHALF OF THE NATION.

65. Cornelius T. Meyers
66. A W. Russel
67. Secretary of War Newton D. Baker
68. J. G. Utz
69. Major James A. Furlow
70. Quartermaster General Henry G. Sharp
71. R. C. McCullough
72. H. A. Reynolds
73. Brig. Gen. Chauncey B. Baker
74. W. F. Norton
75. A. J. Shutt
76. Coker F. Clarkson
77. L. Hanson
78. M. W. Hanks
79. H. L. Horning
80. Grosvenor Clarkson
81. Ray P. Johnson
82. R. E. Freis
83. Mr. Horner
84. B. A. Gramm
87. Captain Murzig
88. Captain Musgrove
89. B. H. Urschel
90. H. Smith
91. L. F. Mann
92. B. Floridey
93. E. G. Gunn
94. R. E. Hood
95. Lieutenant Segraves
96. L. Helt
97. R. E. Lamphear
98. K. F. Walker
99. G. Kinsler
100. Mr. Urch

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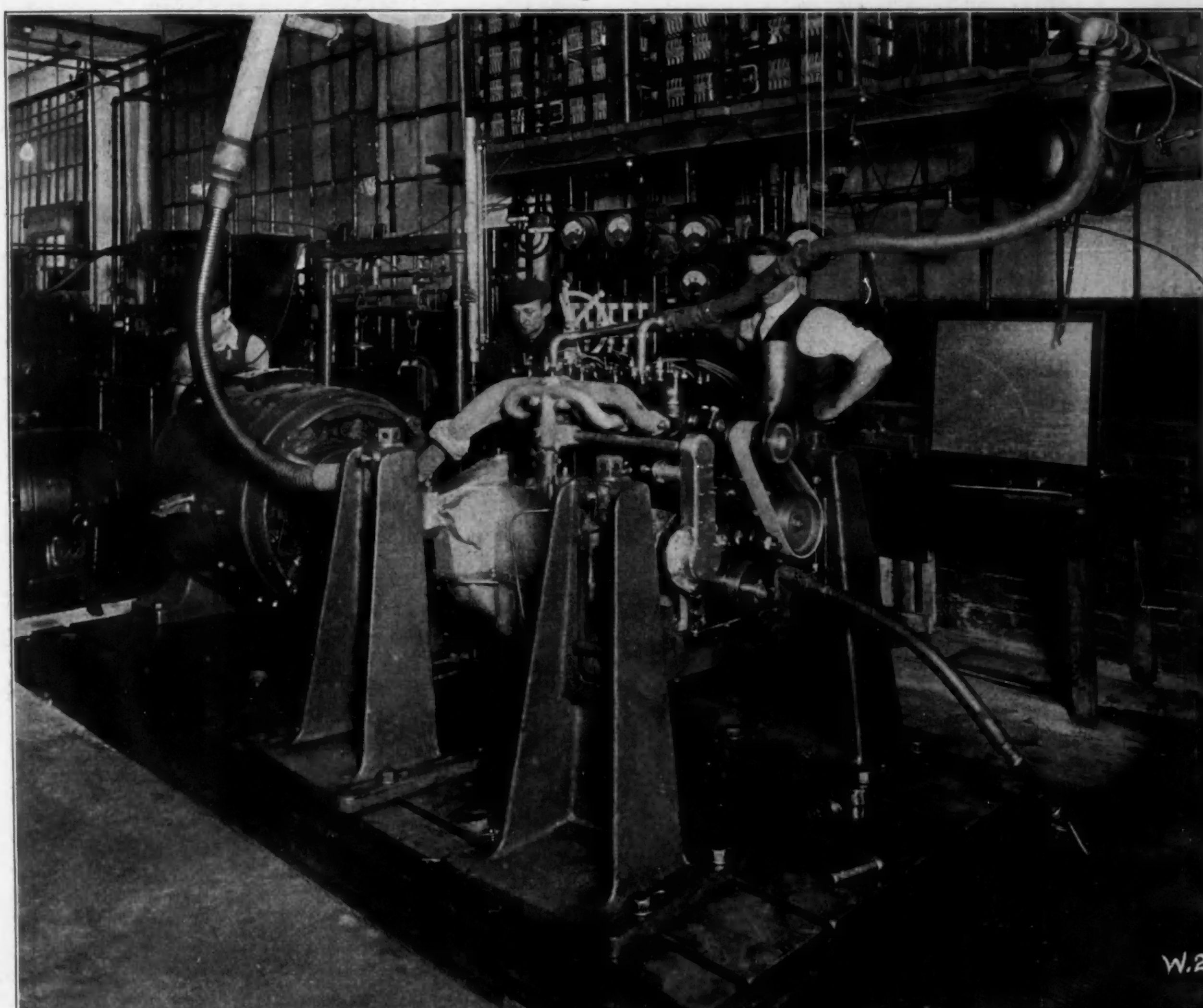
ings were completed. Three sets of sample parts have been ordered. These will be finished, it is expected, by the first of December, so that the trucks can be assembled and in operation by the middle of the month. Less than ten weeks will be required, therefore, for the complete design and construction of the trucks. As an example of the speed with which the work was done, it is understood that the engine was running on the block in sixteen days and twenty hours after the drawings were started.

The B truck was laid out with the idea of using as many parts as possible in the A truck. The general design of the smaller truck, therefore, is much like the larger one, but it is said to follow commercial design more closely because it must be handled over territories difficult for heavy trucks to negotiate. To accomplish such a result the highest grade of materials has been used, thus obtaining satisfactory factors of safety and at the same time low weight.

In designing the truck, the group method used for the Class B work was followed to a great extent, but a general committee first laid out the elements of the truck and determined the fundamental design. These results were submitted to the groups for the production of the actual design of the separate parts. The designs were referred back to the general committee for comment and approval and then submitted to Capt. Wm. M. Britton for final approval.

The engine will resemble closely the one used on the B truck. It is $4\frac{1}{4}$-in. bore by $5\frac{1}{2}$-in. stroke. The four cylinders are cast in block with the cylinder heads in pairs. The manifolds, as shown by the accompanying photograph, are similar to those of the Class B engine.



View of First Class A War-Truck Engine Being Tested by Electric Dynamometer in Continental Laboratory

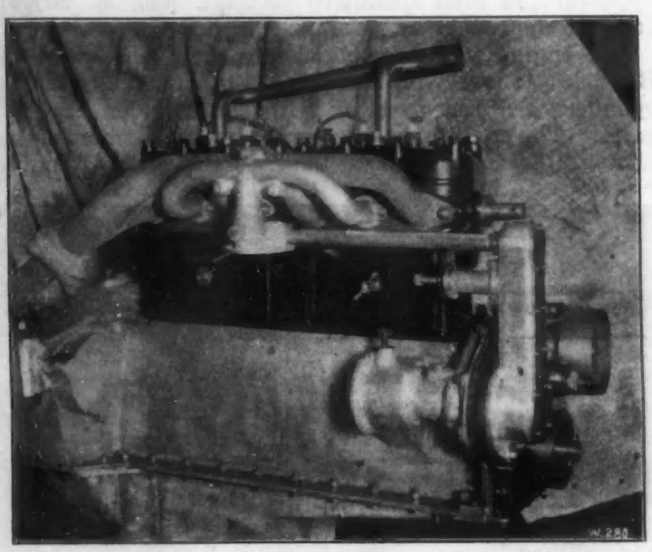
The tests made on the first engine of the A type show very satisfactory results, at least 10 per cent above average performance having been developed.

Important Parts

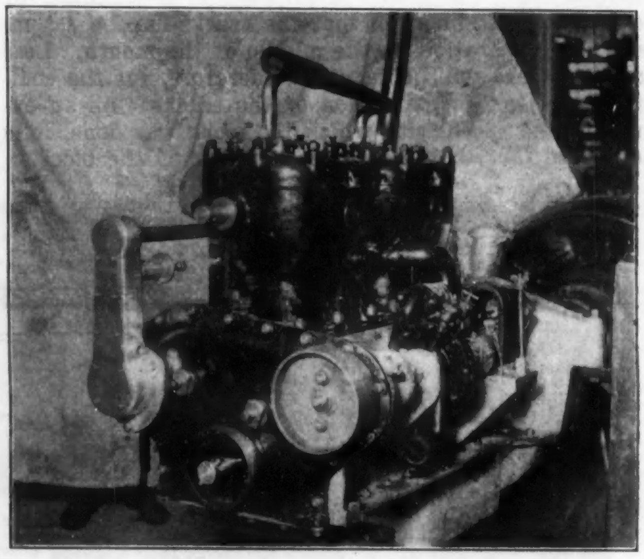
The engine accessories will all be interchangeable on the two sizes. For instance, the same generator and distributor can be used on either the Class A or the Class B engine. The lubricating system is just the same, while the fan mounting has been changed slightly to save weight. The fans are interchangeable, although not the same diameter.

The transmission is of the four-speed selective type similar to that used on the B truck. The gear ratios are as follows: Fourth, 1 to 1; third, 1.7 to 1; second, 3.37 to 1; and first, 5.05 to 1.

The transmission is suspended on an incline to permit



SHOWING MANIFOLDS OF NEW CLASS A ENGINE



FRONT END OF ENGINE DESIGNED FOR CLASS A WAR TRUCK

mounting of the propeller-shaft at the minimum angle. With the internal-gear drive used there is no room for two sets of brakes on the wheels, so that a service brake of the propeller-shaft type has been incorporated with the transmission.

The clutch is similar to the B clutch with the exception that fewer plates are used, so that a correct proportion with the torque output of the engine is maintained.

The rear-wheel axle contains an internal-gear type of drive of special design. This is new and is made up of the good features of present design with a number of special features all its own. The load-carrying member and supports are made of pressed steel. The differential carrier will be much like that used in conventional passenger-car practice. The countershaft is mounted to the rear and above the center-line of the load-carrying member. The differential will be of the self-locking type.

A large number of the B truck brake parts have been used on the A design. The power-shaft brake is of course of the external type while emergency internal brakes are used on the rear wheels.

Both front and rear springs will be centered. The front spring measures 42 by 2½ in. with 9 plates, while the rear is 56 by 3 in. with 11 plates. A unique scheme has been worked out for lubricating the spring bolts. The springs are carried on tubes instead of bolts, the ends of these tubes serving as oil receptacles. When the car is in motion oil is sprayed from these receptacles inside the tubes and then led to the spring eye. Lubrication, therefore, takes place only when the truck is moving.

The frame is of pressed steel, 33 in. wide. The members are of ¼-in. stock, 6 in. deep and with flanges 3 in. wide.

The front wheel bearings will be of the tapered roller type, the rear wheel either of the straight or taper roller construction. Ball bearings are used in the transmission, except that the spigot bearing is of the plain type. The bevel gears on the rear axle have taper roller bearings, while a straight roller bearing is to be used on the spur pinion shafts.

The estimated weights of the Class A truck follow: Chassis with equipment, 5600 lb.; body, 1200 lb.; payload, 3000 lb.; two men and equipment, 400 lb., making a total weight of 10,200 lb. This compares favorably with that of a 2-ton commercial design.

Work Started on Class AA Truck

A special committee is now designing what will be known as the Class AA truck. This will carry a pay load of 1500 lb. The personnel to handle this new work is as follows:

General Committee on Design, H. T. Thomas, B. F. Wright, C. T. Myers and A. W. Frehse.

Engine Committee, H. L. Horning, A. S. Milbrath, W. A. Frederick, Chas. R. Short and Mr. Repine.

Axle Committee, A. W. Russell, R. E. Fries and G. W. Carlson.

Transmission Committee, F. Engle, S. O. White and W. C. Lipe.

One of the most interesting things about the new Class AA design is the fact that practically all the departments of the government having use for a light high-speed truck are interested in it. A committee has been formed representing Ordnance, Engineer, Quartermaster, Signal, Medical Corps, Post Office Department, Navy and Marine Corps. This committee has already held two meetings and has found it possible to settle on a design that will be satisfactory to all. The Ordnance Department, for instance, can use the truck at a speed of about 30 m.p.h. for reconnaissance parties. The Post Office Department will use the truck for parcels post, star route and other service. The requirement here is lightness and durability and it is preferred that the governed speed be not more than 30 m.p.h. The Medical Corps requires a special spring suspension and a low center of gravity on account of the wounded men that are carried.

It is believed that the requirements of all these departments can be satisfied by one design, in which many Class A parts could be used. The Class A engine and electrical equipment may be used for the lighter vehicle.

It is planned to have each department interested prepare a list of the purposes for which it will need such a truck and to give a rough statement of the points for design, capacity, speed, number of gear changes and other requirements, so that a result satisfactory to all can be obtained.

Laboratory Testing in the Automotive Industry

By R. M. Anderson* (*Member of the Society*) Detroit Section Paper

THERE was a time when barred doors and painted windows created about the laboratory a feeling of mystery to the uninitiated. At the present day we are safe in assuming that to go into minute and everyday laboratory routine would be too much like reading yesterday's paper, and shall as far as possible confine this paper to the justification of the large expense involved in the up-to-date equipment; at the same time showing the scope of this division of the automotive industry.

The laboratory measures the capability of a finished unit. The unit represents the assembly of the parts which the factory is to produce or is at present turning out. The laboratory finds out whether the functioning of these parts is up to the predetermined standard. The first run upon a new design is always watched with lively interest. The whole factory is concerned with this initial test.

We can safely say that the most important part of the entire factory product passes through the laboratory. Sometimes the "passing through" is not so rapid. The laboratory must then either justify the correctness of production or determine where the fault lies and correct it. This check upon the functioning of both design and production means security of business for the company.

Improvements in production without loss of quality are measured in careful tests. Even complications in production for purposes of raising the quality of an engine or bettering a competitor's product are shown to be justified by the results obtained in the laboratory.

For these reasons the data furnished by the laboratory must be unquestioned. To obtain accurate results and at the same time to control the disturbing conditions close attention and elaborate equipment are required. Yet the equipment should always be as simple as possible. How results are obtained is frequently as necessary to understand as the results themselves.

Testing Equipment

Instead of the special designs formerly thought necessary, testing equipment can be purchased today on the open market. As far as possible this standardized apparatus should be used, thus avoiding mental calculations in interpreting some other engineer's report.

The length of brake arm, revolution-counting device, gasoline and water metering methods, etc., should be standardized as far as possible. The addition of the aircraft, tractor and marine engines to the work of the laboratory will also require careful revision of tests in order to suit their widely differing needs.

The situation of the engine-testing plant and its general relation to the rest of the factory is of importance to the men conducting the tests. Plenty of light and at the same time of ventilation is absolutely necessary. Unobstructed room around each testing unit must also be provided for in case of fire. Fire danger is greatly minimized and easily controlled if the man operating the extinguisher has freedom of action. This has been demonstrated in tests on large engines when the gasoline stored was not only large in amount but also under high pressure.

Too much stress cannot be laid upon purchasing the best quality of apparatus obtainable and so far as practicable having its operation similar to that of any previous equipment. The operators then do not make unavoidable mistakes at the wrong time.

Cooperation with Men

The requirements in taking readings are increasing rapidly with our intensified war production. Frequent repetitions of long runs for which a large amount of data must be taken have demonstrated the value of military drill applied to testing. Each man has his duty at the switchboard, the scales, the thermometers, etc., and is held absolutely responsible for one detail. After a surprisingly short time the cooperation of these men in meeting the requirements of the test becomes automatic. The data from each man are collected at regular time intervals and the observations carefully inserted at the proper place in the report.

We have also found it of great assistance to plot a graphic log of the run upon a large blackboard. This is in full view of everyone and acts as a moving picture of the engine's performance. The run does not have to be finished before the engine has told its story. Fuel economy, oil consumption and power are observed while the engine is in action and in addition any variation is immediately detected.

The assistants will quickly respond to the training received from repeat runs and will become capable of taking dependable data. We believe that no run of importance should be undertaken until the general performance of the observers is as thoroughly tested out as is that of the engine. The attention of the engineer can then be concentrated upon the test itself, knowing that the chances for error are minimized.

For example, the man handling the dynamometer switchboard will almost anticipate the engineer's signals as regards the speeds and loads upon the engine being tested. This same man with his specialized familiarity of operation can best handle any unusual tests and will clearly understand what points require bringing out.

It is usually the lack of familiarity with a test that upsets the dependability of the result. Or it is equally true that the test is so like a preceding one that the mistake is natural. To avoid this, standardized or rather "familiarized" tests should be used as far as possible.

Standardized Tests

The method employed is something like this: Let us suppose that orders are received or originated for testing

*Prepared by Laboratory Testing Division, consisting of R. M. Anderson, Research Engineer, Packard Motor Car Company, O. C. Kreis, Chief Research Engineer, Continental Motors Corporation, and F. C. Wendland, Laboratory Engineer, Hudson Motor Car Company.

a changed valve material. The foreman of the testing laboratory is referred to the record of a previous test, which has been used successfully to determine the endurance of valves. In this record is given the complete list of apparatus used, which he is to set up together with the engine, obtaining conditions exactly the same as those approved. The engine-speed, load, spark setting, water temperature and other conditions are also given and when he is ready the run is started and the engineer notified. As long as no further notification is given the test is all right and the foreman assumes responsibility, keeping the engineer informed as to number of hours the test has been run and of any unusual indications of good or bad performance. Thus the engineer can determine the length of time necessary to test this valve.

Upon completing the test its writing is greatly simplified. The laboratory record is filed while the final report simply shows that the test was conducted so as to resemble a certain standardized test. The interesting and unusual performances are condensed and compared with other similar tests.

For purposes of furnishing duplicates of the report the first carbon of the typewritten report is reversed so that the first sheet is printed on both sides, making blueprinting possible at any future date. For immediate use carbon copies are distributed to those interested and criticism invited. The original is properly filed for reference.

If it is impossible to use a standardized test owing to lack of similarity or to some new development the foreman receives an order with the details carefully enumerated, following the procedure in standardized tests when such readings as water temperature are to be taken in a regular way. If this test is ever repeated it becomes a so-called standard. The foreman then has no excuse for lack of information about the test, and furthermore the report will be turned in with a careful record of what the set-up actually consisted.

Use of Large Blackboard

As with the graphic log used for long runs we have also found that the use of a large blackboard bearing the captions and rulings of the curve sheets is of great value. The performance of the engine on its last test is plotted upon the blackboard. The values of "pounds pull" are written directly upon the curve where it intersects the values of revolutions per minute. Thus on the repeat run with the "hopeful" changes made we can compare quickly the scale readings with those secured before.

The blackboard can be used with equal effect for a generator test, when a comparison is to be made with what is known to be a good output. The blackboards are hung from the ceiling with counterbalance weights thus making possible their immediate use or removal.

Quite as important as the excellence and accuracy of the equipment is the decrease of the time element for set-ups. Weather conditions may be such that an unusual result is noted. To get a picture of this same phenomenon on another type of engine or with a proposed means to eliminate its effect requires fast work. Of course the ideal method is to have several dynamometers, but even then the extra engine may not always be set up waiting for the condition to arise.

So far as possible the minor measuring instruments should be carefully calibrated to read in units that will save unnecessary calculations later. Whenever calculations are unavoidable, the readings should be made in tenths of time intervals or quantities as the case may be.

Frequently it is necessary to check the actual fuel consumption before tests that do not involve the carbureter are made. A large quantity of gasoline must be weighed before accuracy is assured. Many laboratories are consequently using a volume-measurement in place of weight. The volume can be constant and the time measured, or the volume can be variable and the time constant. For testing automobile engines the former method is preferred. Any arbitrary amount can be taken but for easy calculations a tenth of one gallon is convenient, this being governed, of course, by the horsepower to be measured.

A container can be made of large glass tubing with both ends reduced in area. The small ends are provided for close readings. The tube is calibrated with a standard burette for whatever quantity is to be used, and the limits indicated at both ends. The lower end is connected with a three-way valve and piped up so that the engine does not have to be stopped during any of the operations necessary to measure the fixed quantity of fuel. Very accurate readings can be quickly made with this instrument.

Value of Venturi Meter

For measuring the engine cooling-water venturi meters will be found invaluable. These simple instruments can be safely relied upon for accuracy within 2 or 3 per cent and can be purchased complete with manometer calibrated for gallons, pounds or cubic feet per minute.

The serviceability of the venturi meter is illustrated by an engine test in which the load was varied but the speed maintained constant. The pump speed was a function of the engine speed, thus eliminating it as a variable so long as the engine speed was constant. The first engine used was entirely conventional in design; this was also true of the one used later as a check. The water-outlet temperature was kept as constant as it would be on any similar test and likewise every other disturbing element was accounted for.

While making the second test the reading of the manometer connected to the water venturi meter was noticeably higher than that for the first run. The main difference in the first and second runs was that the load in the latter was three times what it was in the first. This increased manometer-reading was also remarked when the load was still further increased to a maximum.

That the amount of water circulated was seemingly a function of the power led to further investigation. The particular engine tested was believed at fault, so after the run was concluded and the other purposes of this test accomplished it was decided to test a different make of engine. It was hoped thus to prove or disprove theories based upon the construction of the original unit. Particular attention was paid to duplicating everything except the variable reading upon the venturi meter, but the tests failed to show any results differing from those in the original engine. The rate of water circulation seemed to be also a function of the power in this second engine.

As a further check some trustworthy tests of a similar nature were looked up. One in particular showed a like result; namely, one made several years ago by Herbert Chase* on a Pierce-Arrow engine. This was remarkable for the fact that the water-pump capacity was carefully measured with the engine turned over by a dynamometer; the result therefore was not effected by any heat generated within the cylinders, as of course there was little if any heating of the water. Later with the engine run under its own power, it was clearly shown that the

*S. A. E. TRANSACTIONS, 1912, Part II, p. 140.

amount of water actually circulated had increased as compared with that required for the engine cold at the same speed. But let us not lose sight of what we started out with. This interesting disclosure, showing the value of minor instruments, was really the result of having a carefully calibrated water meter which read directly in pounds.

With carefully built instruments and the proper handling the laboratory is capable of writing for the company a valuable history of its work. If history must repeat itself it should be along the line of design that has been proved sound and lasting. The executives of any organization know the paying models. But the laboratory must write this history so as to make the causes of good and poor design stand out, thus securing a successful future to the particular company and to the industry as well.

The laboratory data should be constantly compared with actual results in service if the designer's success is to be based upon them. For this reason it is well to have similar subjects so arranged that service and laboratory reports will be filed together.

An engine for its particular field requires an exhaustive study of the conditions of that field. It is absurd to apply all the tests to a truck engine which are necessary for one to be used on an automobile. Similarly the tests upon an aircraft engine are far different from those upon a tractor engine.

Economy runs on automobile engines at wide-open throttle and full load give very little indication of the actual road economy. They do, however, materially assist the carbureter engineers to correct faults. But the average automobile is driven with a partly closed throttle under conditions quite different from full power performance. Our new specifications for testing such engines reasonably insist upon various throttle openings throughout the speed range.

As an example the throttle openings for various road conditions on the level can be measured in degrees to correspond with the speed in miles per hour. These positions can then be used in the laboratory at engine speeds corresponding to car speeds and a fairly close approximation made of road economies. The same power data can be used with benefit to make the relations of the laboratory and the road still more valuable.

Testing of Accessories

In order to be entirely familiar with the parts that make up the finished unit and to comprehend the design properly, it should be possible to test such parts as the cylinders, water-pumps and crankshafts adequately in the laboratory. This will frequently avoid a delay in taking parts some distance away in the factory when a special test is used in the production.

Accessories, such as generators, starters and ignition devices, purchased outside are of course tested before installation on the engine. It has been found of great assistance to plot the capacities of such accessories not only on the usual basis of revolutions per minute but also according to the corresponding miles per hour.

The value of the torque required in the starting motor to turn the engine at a given speed should be furnished the builders of the electrical instruments. This torque, however, is not the one that the dynamometer will register when connected to the flywheel. If the latter be used the large inertia of the armature will produce false results; the error increasing as the number of cylinders is decreased.

The test should be made through the transmission used with the starting-motor installation. The starting-motor pinion is fastened to the armature shaft of what is really a small high-speed dynamometer, thus enabling the torque required to be more accurately determined.

The cooling of engines of present-day construction is a problem requiring attention since the changes in fuels tend to upset previous standards. For instance, with kerosene as fuel the cooling difficulties are increased, but the extent has not been determined.

Engine Cooling Systems

Should the cooling system prove inadequate at the height of the season so as to interfere seriously with the car's service, there is but one choice for the manufacturer, namely, to correct it. To do this tests must be made to establish the causes of the difficulty.

The test is made as follows: the pump capacity is measured and the solidity of flow at all speeds analyzed; this is then compared with the radiator flow to take care of maximum speed at which car can be driven. If the radiator will not "flow" the requisite amount, the water piles up at the inlet and in time overflows. This rapidly empties the system, and boiling is a result. The baffle in the inlet to deflect the water rushing in to the sides of the tubes must be studied. Good distribution over the top area of the radiator will render effective the full frontal area of the cooling surface.

Tests must also be made to check the effectiveness of the fan in free air and also in the standard car-installation. The volume of air passing through radiator at the critical speed can be determined easily by driving the fan from a variable-speed electric motor, cutting a small space in the hood for the belt to pass through and coupling the front of the radiator shell to a flexible boot, which makes a tight connection with an air-measuring tube at the front of car. The advantage of increased louver-area and free space about an engine using a constant fan speed can be determined. Consideration must also be given to the additional air due to the velocity of the moving car, this being independent of the fan requirement.

On account of the engine a separate analysis is required of conditions existing between the carbureter and the cylinder water-spaces. Improper shunting of the water will produce eddies and ineffective circulation. Too much water can be circulated at a point not requiring cooling, and vice versa. The design must be such as to eliminate foundry difficulties, for these are not evident from the outside and can be determined only by cutting a cross-section through the cylinder. Water should be circulated at a rate to correspond with car speeds and its flow studied for improvements.

Obtaining Operating Conditions

When the various difficulties are "ironed" out the working of the actual engine must prove its effectiveness. Taking the low speed at which the car will negotiate hills of sufficient length to bring out heating troubles, various loads are applied so that a curve can be plotted showing the difference in inlet and outlet water temperatures. To obtain this the outlet temperature is held constant and the inlet varied. Though rough, this test will show whether the engine performance falls within the limit of previous practice. Should the difference be large, a correction should be made before proceeding with the final and more elaborate test.

In the final test two identical tanks are required. These are constructed in such a way that the outlet and

inlet passages correspond to the pump intake and water outlet of the engine to be tested. These passages thus established will also fit the corresponding ones in any radiator adapted to this engine. Each tank should hold about 600 lb. of water. This includes necessary pipes, water-pump, etc., outside of the engine itself. The tanks and pipes are carefully insulated against heat loss by means of boiler covering.

The bottom pipe of the tank is directly connected to the pump intake of the engine; the upper pipe of the tank is connected to the cylinder-outlet passage of the engine. The tank is simply a reservoir in which sufficient water is stored so that the engine can run long enough for the proper readings to be taken before the water commences to boil.

Description of Test

The set-up of this tank with the radiator is about the same as with the engine with these exceptions: The lower outlet of the tank is connected to the suction side of a separately driven pump, and the water forced into the bottom of the radiator to be tested. The upper pipe of the tank is connected to the upper passage in the radiator. The direction of the flow of water through the radiator therefore is the reverse of what it is in actual practice. In addition to the separately driven pump, a fan is placed behind the radiator, as far as possible in the exact location used in the chassis. The pump and fan, however, are driven by separate electric motors, so that the rate of circulation of both water and air can be varied in order to measure their influence accurately.

The tank is filled with water to a point easily observed by reducing the top area to a small neck of about 6-in. diameter. This is marked to correspond with a known quantity of water in the system. The engine is then started and allowed to run at a fixed load and speed until constant heat conditions are obtained. As the engine runs the temperature of the water will obviously rise. This temperature, both when entering and leaving the cylinders, is read by thermometers. When the temperature of the water supplied to the engine rises to 110 deg. fahr. the stopwatch is started, and the time, in minutes and seconds, is noted for each 5 deg. rise until a temperature of 150 deg. is reached. This then represents a rise in temperature of 40 deg. for a measured interval of time. With the weight of water known, it is a simple matter to calculate the British thermal units that the water has absorbed from the engine and then to reduce them to British thermal units per minute.

The radiator tests are similarly conducted, except that the temperature of the circulating water should be above 150 deg. before starting. The stopwatch is started at the time when the average temperature in the tank drops to 150 deg. For each decrease of 5 deg. the time is noted until a temperature of 110 deg. is reached.

The fans, both in the engine and radiator tests, are driven at a speed that will circulate the volume of air corresponding to that due to the road velocity of car plus the fan displacement. If any variation is allowed the volume must be less, rather than greater, than this.

Both engine and radiator tests are run simultaneously, thus responding alike to any change in room temperature or to atmospheric variations. The interval of time should be equal for engine and radiator if the radiator is to handle the cooling efficiently for the given conditions, and this also helps to limit the variation of factors. Boiling results when the engine with a particular load requires less time for heating than the radiator requires to cool the same amount of water. In actual tests made by this method the average of results so far obtained check within about 3½ per cent.

Obviously, either test can be run without the other for comparison of engines or radiators. But this necessitates constant conditions of room temperature and has to be made with care. For general analysis of the engine heat-loss it is very valuable. This loss can be determined and used as a satisfactory record for basic comparisons. The British thermal unit per horsepower per minute gives the radiator manufacturer a figure of value in designing his product. Quite as important however are the pump flow in gallons per minute and the fan displacement in cubic feet of air per minute.

Some of the difficulties that must be guarded against in cooling tests are: high friction horsepower, insufficient radiating surface or radiator flow, leaks from combustion chamber to jacket space, incorrect spark manipulation, muffler back pressure, hood back pressure, carbureter setting, and preignition from spark-plugs.

Spark-plug Testing

With the introduction of the highly developed present-day engine we have found changes necessary in many details. One of the developments has been in spark-plugs, their proper ability for carrying away heat and their location. About the first item to be observed in testing porcelain spark-plugs is the breakage. Porcelain is broken by sudden changes from heat to cold, especially in high-speed engines.

After the electrodes have been adjusted the plugs are installed in the engine, which is connected to a dynamometer. With the water at room temperature or less, the engine is started and the throttle quickly thrown wide open to let it reach its maximum speed. After about one minute at high speed the ignition switch is opened and while the engine is slowing down it should be noted if any preignition occurs. If upon examination the porcelains are not cracked, another run can be made at maximum torque with the engine still cold.

After these two runs, the heat test can be made. The temperature of the water should be brought close to the boiling point and tests made at low speed, wide-open throttle, at maximum torque, and at the highest speed of the engine.

During these tests leakage can be observed at the top and around the base of the porcelains. The top and the base of the porcelains can be given an oil bath to show up compression or explosion leaks. Usually porcelains are cracked during these tests. A cracked porcelain can be instantly recognized if the spark is retarded just enough to stop spark knocks; the cracked or broken porcelain will immediately cause preignition.

Tests for Preignition

If on previous tests the porcelains withstand the hard abuse, tests for preignition can be made as follows: The engine being started and given full load at a low speed, the outlet water should be at about room temperature at the start and gradually increased with sufficient spark advance for the best torque of the engine. Tests should be made of at least five minutes, during which time one must be on the alert for knocks. If the engine develops spark knocks, the spark may be retarded a trifle; if knocking does not cease, open the ignition switch with the throttle wide open and observe whether the engine still fires with the switch open. If it does the firing is generally accompanied by sharp, hard knocks, and the en-

gine will run for some time firing occasionally, which indicates bad preignition.

In making these spark-plug tests, it is assumed that the engine characteristics are known. The characteristics of a new engine require analysis for determining the limit of its power. A manifold change can produce surprising results. After a change of this nature had been made upon an engine the power was noticeably greater and the depression higher than with the small carbureter used in previous tests.

In other words, the breathing of the engine had been improved by supplying all cylinders with an equal, or more nearly equal volume. A manometer at each cylinder port is of great assistance to determine this. With a cylinder that is robbed of charge the depression will be higher than with those that are satisfied. The mixture balance can also be checked by running the engine with the exhaust manifold removed. Much piling up of raw gas can be eliminated by preventing its formation from hot-spot heating.

The Discussion

CHAIRMAN C. C. HINKLEY:—The object of this paper has not been to go into the technical and detailed end of the laboratory. What was desired was merely to touch such points as are problems to designers of internal combustion engines.

A MEMBER:—What is the average efficiency of the ordinary passenger-car transmission and of the rear-axle, if the engine is running at maximum torque?

R. M. ANDERSON:—In general I think the loss in each train of gears is not more than about 3 per cent. The loss might be slightly greater than 3 per cent in the rear-axle, owing to bad alignment.

Acceleration Tests on the Block

L. ARNSON:—Why has not an acceleration test ever been made on the block? What is the difficulty of making such a test? After we get through testing an engine and a carburter, we obtain curves showing fine economy. When we put the outfit on the car we have to change the adjustment of the carbureter. After the test is made of maximum acceleration on the block, why not make a characteristic-curve test?

R. M. ANDERSON:—Acceleration tests have been made on the block to show, for instance, how the engine speed picks up; but the chief difficulty is that the power required for each increment of acceleration cannot very well be obtained with the dynamometer unless the load is continually increased. A fan rigged up in place of the dynamometer would show much better how the engine would accelerate under those conditions. Of course, the inertia of the car would have to be compensated for by means of some added weight like a heavy flywheel.

L. ARNSON:—I was referring to a comparative test on the same block of the same engine with a different carbureter, or of a different engine with the same or different carbureters. I should think a device could be arranged whereby some sort of centrifugal governing device could be calibrated so that contacts could be made as the speed increased, say from 300 up to 1200 r.p.m. in order to have an appreciable time elapse.

R. M. ANDERSON:—That would be quite possible and certainly would be interesting to work out.

A MEMBER:—Has a test ever been made at different speeds to see how much of the air entering the hood comes out, the action of air inside the hood being kept up?

R. M. ANDERSON:—Such tests have been made. At least 70 per cent of air should come out. We can duplicate road conditions so that the whole equipment is the same as it is in the chassis.

MR. JOHNSON:—What fuel increases the difficulty of operation?

R. M. ANDERSON:—With kerosene all the heat problems are increased. The engine must be cooled differently; more efficiently if possible. A larger amount of water and a larger radiator would have to be used to handle a kerosene engine properly. The fuels of the present day are taking on more and more of the heavy products of kerosene so that we must be prepared to expect results such as those obtained from straight kerosene.

E. J. MCMULLEN:—Is it possible to apply too much heat to gas going into an engine? If so, what is the highest successful temperature that can be applied to that gas?

R. M. ANDERSON:—I think the cooler the gas can go in, the better. I have seen kerosene engines run on air that was cold when it arrived at the intake valve. No heat at all was added to it, and yet maximum efficiency was secured in that way. Just as soon as the air was heated the power commenced to decrease. Most of the new kerosene carbureters are designed to keep the air just as cold as possible, if not in the closed throttle position certainly in wide-open. The ideal, of course, is to keep the volumetric efficiency as high as possible by reason of the cool incoming gas.

E. J. MCMULLEN:—Then the only good reason for heating the gas in an automobile engine is simply to assist in vaporization?

R. M. ANDERSON:—After the carbureter has started the mixture in the right direction and in the right proportion, and has broken it up fairly well, it has performed its function; but so many interfering factors between the carbureter and the inside of the cylinders can precipitate the liquid that heat is used really as an insurance against any wet spots forming.

Where any wet spots have been found to form, the much-used hot-spot is a great advantage, because it revaporizes the fuel, or prevents it from going into a liquid state, without changing materially the temperature of the coming air.

E. P. OSWALD:—Has a test ever been made at different outputs with different kinds of currents applied to the spark-plugs? What I mean is, by high frequency, high or low potential, or a greater energy, in order to obtain a greater amount of heat in the spark. I made some tests recently with some wonderful results. I got 15 per cent more horsepower in a dynamometer test with less heat in the spark; that is, less current with the same watts, and higher potential.

Air-Cooled Airplane Engines

A MEMBER:—What is the chief objection to the air-cooled engine for airplane work?

R. M. ANDERSON:—Of course, the rotary engine has cooled itself pretty well, but the experiments have not gone far enough to show really what an air-cooled non-rotating engine would do.

A MEMBER:—Most of the engines make a five or six-hour flight. The gasoline for that flight weighs more than the engine, so that it is important that the engine should be very economical in gasoline; this means a very high compression, sometimes up to 130 lb.; in an air-cooled engine the highest compression that can be cooled efficiently would be about 75 or 80 lb.

A MEMBER:—In attempting to get maximum efficiency from automobile engines, is the problem to keep the gas at the proper heat or is it necessary actually to keep the cylinders hot?

R. M. ANDERSON:—If the cylinder is too cold the fuel will be precipitated on the compression stroke. The amount of heat within the cylinder must be sufficient so that precipitation due to compression will not separate the fuel from the air.

A MEMBER:—What would be the minimum cylinder-wall or water-jacket temperature that would prevent that condition occurring?

R. M. ANDERSON:—The temperature might be somewhere around 200 or 220 deg., although I think it is much higher.

G. D. BROWN:—Have you ever made any tests to get the temperature of a piston?

R. M. ANDERSON:—No, I never have. If anybody has any method, except from observation of the change in color of the material, I would like to know about it.

A MEMBER:—We have tried running the water-jacket space away down to the bottom of the cylinder. The compression can then be much higher without having preignition than when the water-jacket stops at the lower end of the stroke.

Gas Temperatures

D. T. RANDALL:—As near as we could determine, the gases entering the cylinder gave good operation down to a temperature of about 120 deg., and also gave practically the same operation up to about 170 deg. It is difficult to measure the temperature of the mixture going into the cylinders. That was the nearest we could get to it. We had the same experience with gas engines. Of course, the question of compression does not enter into it at all, but it shows that practically the same efficiency is obtained with gas at say 130 or 140 deg.

A MEMBER:—Has the temperature been determined at which the incoming gas can be said to be rarified?

CHAIRMAN HINKLEY:—We put it this way: What is the maximum allowable gas temperature that can be used without a falling off in the volumetric efficiency?

R. M. ANDERSON:—I found the best temperature of the ingoing gas to be about 90 deg. throughout long periods of time. This may not give as much power in some of the warmer months, but throughout the year in the general operation will be much better. The temperature is high enough to secure satisfactory operation on days when it is a little bit hard to start.

CHAIRMAN HINKLEY:—The liberty-truck engine has a hot-spot intake-pipe. Under actual test that spot in the center of the intake-pipe gets so hot that water poured on it will boil; it gets practically as hot as the exhaust pipe, and that spot is so designed that dry gas goes into the engine. The pipe has exhaust gas around two-thirds of its periphery. That is, it goes over the top and under the bottom and around the neck where the gas comes up to the carbureter. About 3 per cent would be the maximum power loss due to the decrease in volumetric efficiency caused by heating the incoming gas.

FRANK JOHNSON:—How high a temperature will porcelain spark-plugs stand before they crack?

R. M. ANDERSON:—It is not the actual temperature as much as it is the contrast of temperature. For instance, if the plug is cold, and it is suddenly heated; that is what produces the cracking, because the porcelain is a poor conductor and does not expand fast enough. On the other hand, if a hot plug is suddenly cooled cracking would result just the same.

G. D. BROWN:—I should think that fault could be overcome to a great degree by increasing the compression of the engine, and by increasing the cooling efficiency at high speeds.

GEORGE E. GODDARD:—Has Mr. Anderson ever made any tests to determine the maximum and minimum temperature for the best mixture of the gas? Why I ask is that probably all of us have had some experience with a casing-head gas plant in the vacuum system. The casing-head gas cannot be used at as high a temperature as the regular gasoline. It seems to cause more bubbles in the carbureter.

R. M. ANDERSON:—In the first blending that we had on this new formation of gasoline the casing-head gas was mixed with some of the heavier fuels. The lighter fractions would then respond so easily to any temperature increases that they would come out in bubbles from the spray nozzle and the top of the float chamber. The first point in controlling temperature for either gasoline, kerosene or any of the hydrocarbons would be the boiling point of the liquid, so that the carbureter should not get so hot as to start the boiling process in the lowest fraction of the combined fuel.

A MEMBER:—Will not all the liquid fuel be vaporized before being distributed in the induction pipes in the various cylinders, and is not the present method of distributing liquid fuel in the spray form wrong?

R. M. ANDERSON:—I think the vaporizing of fuel will be done largely within the cylinder. It would be practically impossible, without decreasing the volumetric efficiency, to preheat the air to such an extent that it will hold in suspension the heavier fuels which must be used later. The only way I can see is to use the temperature that will secure flexibility with the mixture, and then have the rest of the vaporizing take place, if possible, within the cylinder. One vaporizing process would be to take a hot piston and use the heat there as latent heat of vaporization so that the final temperature would not be as high as before the incoming gas started to vaporize.

A MEMBER:—That was not exactly my question. I believe it is necessary not to heat all the air, but to vaporize the fuel and as little air as possible, as is being done in some of the kerosene vaporizers.

R. M. ANDERSON:—That would be a good move, but I do not believe it is absolutely necessary.

CHAIRMAN HINKLEY:—Can that be done satisfactorily without condensing the hot fuel the instant it strikes the cold blast of air?

Distribution of Gasoline

A MEMBER:—In about 100 small towns in this country gas for domestic purposes is made from gasoline, and which is carried several miles, and yet it is considered a hard problem to distribute it a couple of feet in an engine.

CHAIRMAN HINKLEY:—The apparatus that delivers gasoline a couple of miles is also provided with the necessary settling chambers and sumps to take care of the extra condensation.

A MEMBER:—Yes, but there is no condensation in any part of the two-foot system worth considering. Of course, in these local systems it is brought to a high temperature, is vaporized, fixed and can be carried some distance in that way, whereas on engines present, the practice is simply to warm the fuel slightly, and then mix it with the air. I believe a great deal of our trouble is due to condensation, wet spots in the intake making necessary these hot spots.

CHAIRMAN HINKLEY:—Is the gas used in small-town illumination perfectly dry?

A MEMBER:—It is very dry as compared with the gas that we are using in engines.

CHAIRMAN HINKLEY:—What is the velocity at which that gas is carried?

A MEMBER:—The velocity is not very high as the pressure is anywhere from two ounces to two pounds.

CHAIRMAN HINKLEY:—I think the velocity, or the rate the particles impinge on the cooling surface, has a great deal to do with whether that gas will condense.

G. D. BROWN:—In one case gas is being made in the carbureter, and in the other it is just being transferred from one place to another.

R. M. ANDERSON:—Is not the time element larger in the formation of illuminating gas? For instance, in the carbureter the gas is made instantaneously and in tremendous volume. There is a chance for natural evaporation in a gas machine that it is absolutely impossible in any carbureter.

CHAIRMAN HINKLEY:—What percentage gasoline does the gas plant mix with air? How does that compare with the mixture as we use it in internal combustion engines?

A MEMBER:—It is about the same as is used in the engine.

CAPT. A. B. BROWNE:—In these gas producing plants, what residuum or proportion of the total amount used is left in the generator?

A MEMBER:—I do not know the exact proportion.

CAPT. A. B. BROWNE:—It seems to me that one or two fundamental principles are being overlooked in this discussion. In the first place, is the loss in volumetric efficiency detrimental? Is it a fact that the density of the gas decreases in considerable proportion to the temperature and increases with the pressure? We should look to the distillation curves of various compound fuels in use.

In the old days the so-called 76-deg. gasoline burst into vapor the moment pressure was released on it at the mouth of the carbureter nozzle at normal atmospheric temperature. Today it seems that any fuel can vaporize provided the temperature is raised and the pressure lowered sufficiently to bring that condition about. Dr. Lucke has made the statement that dry kerosene vapor mixed with air in combustible portions can be maintained at a temperature of about 250 deg. fahr.

I do not remember just what the volumetric loss would be at that point, but it seems not to be prohibitive. If a dry gas is used in the cylinder, the condition is very different than we get if a spray or even a fog mixture is used.

Advantages of Dry Gas

A fog mixture is used in one device recently put on the market, and I understand that it has been successful abroad; a vaporized fuel is subsequently condensed in the form of fog in the intake pipe or manifold. The fog mixture is undoubtedly combustible and has the advantage of cooling the piston and the cylinder walls by its latent heat of vaporization. The fog mixture seems to be advantageous, but many believe—and I must confess I am one of them—that we are looking for dry mixtures, and that we can well afford to sacrifice a certain amount of volumetric efficiency for the sake of producing dry gas.

The gas apparatus mentioned was prevalent a few years ago. The gas was made in non-combustible proportions, subsequently burning in the air with the addition of oxygen from the air, which made it safe for general transmission. I think it will be found that if this apparatus is used to any extent today a large percentage of residuum is left in the generator. One method has overcome that successfully by utilizing all of the heavier fuels, but if we are to utilize fractions distilling at upward of 650 deg., or if we are to utilize all the fuel, we must modify our engines to meet the loss of volumetric efficiency.

Result of Preheating Mixture

W. TAYLOR:—Is it not true that the thermal efficiency can be increased by preheating the gas mixture? Possibly the residuum might be decreased, but would not the thermal efficiency be increased?

R. M. ANDERSON:—Yes, I think it would.

CHAIRMAN HINKLEY:—I have seen that increase amounting to as high as 10 to 15 per cent by decreasing the volumetric and increasing the thermal efficiency, or increasing the burning capacity of the fuel, which otherwise was lost through the exhaust.

A study is now being made of gas flow in the combustion chambers, and it has been found that the proper shape of such chambers, especially around the exhaust valve, has a great deal to do with the increased output of the engine.

The combustion-chamber form now commonly used, which have been developed in the last two years, is an improvement over the old flat form as regards not only the gas flow, but also the water flow at the top, which eliminates the hot spots. Instead of letting water bubbles stay at the top and going off the minute a hot spot results from preignition, there is actually a flow. Directing the water around the exhaust valve, confining it almost exclusively around the exhaust valve, permitting very little leakage around the other parts of jacket; all these tend to increase the efficiency.

G. D. BROWN:—I made one experimental job so that all intake gas coming into the engine had to pass over the exhaust valve. Instead of making the engine in the L-shape, in the usual sense of the word, I placed the exhaust valve so that all intake gas passes over the exhaust valve. It would be a very big help if the present engines had something of that kind.

CHAIRMAN HINKLEY:—There is just one objection I see to that. It would give a long L-head construction and there would be a run-by of dead gas on the compression stroke, so that the hot gas would be compressed back in the pipe and result in a preignition.

The preheating of gasoline has been rather given up, except for starting purposes, because the gravity is changed and when it is led to the float chamber the whole function of the carbureter is altered. A slight amount of heat on the carbureter intake-side is good for breaking up the gas, but my experience has always been that the heat should be applied after the gas leaves the carbureter and before the gas enters the engine.

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Problems of Crankshaft Design

By OTTO M. BURKHARDT* (*Member of the Society*) BUFFALO SECTION PAPER

GUIDED by a purely sociological motive I wish at first to call attention to the fact that at least three groups of scientists are remarkably interested in one and the same problem, namely, the problem of balancing. To be specific: the economist is seeking "the balance of trade"; the statesman is eagerly watching "the balance of power"; and last, but not least, the automotive engineer is developing "balanced crankshafts." This common endeavor is easily understood if we realize that from the creative force which develops and maintains this universal order, or cosmos, we have inherited a sense reluctant to things out of balance.

However, the most extraordinary feature of this apparent parody is its culmination, which happens to be an indisputable fact, namely, that the balance of power depends on the balance of the internal combustion engine, for it has been stated that the internal combustion engine may win the war. This would at once elevate the type of prime mover which we endeavor to balance to the highest of all achievements; that is, the means to make the world safe for democracy.

Gasoline engines, of the kind at present produced in large quantities for airplanes and motor vehicles, may turn over at 3000 r.p.m. or faster. The forces necessary to induce and maintain these speeds, as well as other forces closely associated with high speeds, are numerous; but with a particular object in mind, we shall in the following confine ourselves to the three most important groups of forces—the pressures due to the gaseous mixture, the inertia forces, and the centrifugal forces. The smooth running and the life of an engine depend mainly on these three factors.

We shall consider the reciprocating masses linked to the crankshaft as one mass concentrated at one point in the axis of the cylinder. This simplification implies that the inertia forces are, like the gas pressures, acting primarily in the direction of the cylinder axis, a condition that permits arithmetical addition of both groups of forces. To the same category belongs another group of forces, which has, according to a well-known law, its origin in the angularity of the connecting-rod. The different component forces have been determined in respect to two engines of equal capacity for twenty-four crank positions. These positions are uniformly spaced at intervals of 30 deg. and comprise two revolutions, which constitute one complete cycle in case of four-stroke cycle engines.

TABLE I—DIMENSIONS AND WEIGHTS FOR ENGINES OF SIMILAR DESIGN

	Six-Cylinder	Twelve-Cylinder
Cylinder bore, inches	3.75	3.00
Stroke, inches (bore × 1.667)	6.25	5.00
Weight of reciprocating parts, pounds (one cylinder)	4.07	2.60
Weight of rotating parts, pounds (one cylinder)	2.40	1.93
Weight of rotating parts, pounds (two cylinders)	....	3.86

Corresponding components when combined as resultant forces and graphically represented in magnitude and direction yield irregular characteristic diagrams with which every engine designer should acquaint himself.

*Mathematical Research Engineer, Pierce-Arrow Motor Car Company.

As subjects for investigation, medium-size six and twelve-cylinder engines, both of the same cylinder volume, were chosen. Both engines are supposed to be similar in design and up to the same standard of engineering. Some particulars relating to these engines are given in Table I.

Fig. 1 is a force diagram pertaining to the six-cylinder engine. The concentric circle is a graphical representation of the centrifugal forces acting on the crankpin at a speed of 2700 r.p.m. The combined gas and inertia forces as above referred to are represented by the zigzag diagram.

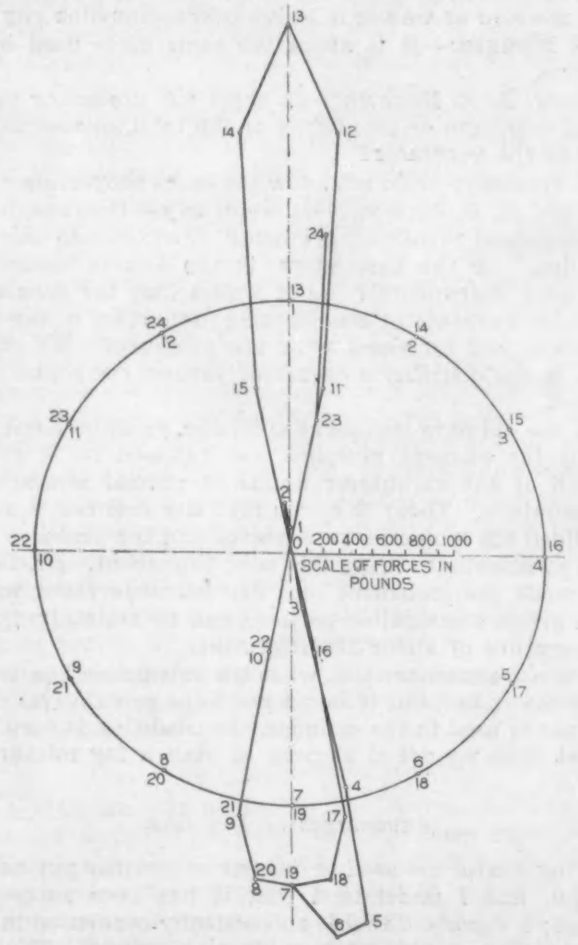


FIG. 1.—CENTRIFUGAL FORCES AND COMBINED GAS AND INERTIA FORCES ACTING ON CRANKPIN OF SIX-CYLINDER ENGINE

For instance, *O-3* of this diagram represents magnitude and direction of the combined gas and inertia forces if the crankpin is in position *3*, that is, 60 deg. apart from the top dead-center. For one complete cycle we find that the different strokes are represented as follows:

Power stroke, by forces *O-1* to *O-7*.
Exhaust stroke, by *O-7* to *O-13*.
Suction stroke, by *O-13* to *O-19*.
Compression stroke, by *O-19* to *O-1*.

In order to obtain a clear picture of the total forces acting on a crankpin, we must combine both diagrams as follows: *O-1* of the zig-zag diagrams with *O-1* of the concentric circle diagram, and so on. This yields the diagram shown in Fig. 2, which represents magnitude and direction of the resultant forces acting on the crankpin of a six-cylinder vertical engine.

The combined gas and inertia forces for one unit of a twelve-cylinder engine and the corresponding centrifugal forces are diagrammatically represented in Fig. 3. We observe that these forces are much smaller but quite analogous to those given in Fig. 1. The combination of the gas and inertia forces with the centrifugal forces yields the diagram shown in Fig. 4, which represents magnitude and direction of the resultant forces per cylinder, acting on the crankpin of a twelve-cylinder engine. We must bear in mind, however, that in the case of the engine under consideration, two single-cylinder engines are acting on one crankpin. We have therefore to superimpose two diagrams so that their vertical axes include an angle of 60 deg., as in Fig. 5. The crank positions *1* to *24* in the diagram are plotted according to the clockwise rotation of the crankshaft. The distinction between the right- and left-hand block of cylinders is made through the indices *R* and *L* by similarly viewing the engine. According to the conventional sequence of firing, we obtain: *1L, 6R, 5L, 2R, 3L, 4R, 6L, 1R, 2L, 5R, 4L, 3R*. From this we see that the engine on the right is in phase 420 deg. behind the other, or (what is to the same effect) 300 deg. ahead of it. It follows that we must combine force *O-1L* due to the left-hand engine with force *O-11R* due to the right-hand engine and so on. Properly carried out for all simultaneous acting forces, this yields a diagram, Fig. 6, representing magnitude and direction of the forces acting on the crankpin of a twelve-cylinder V-type engine.

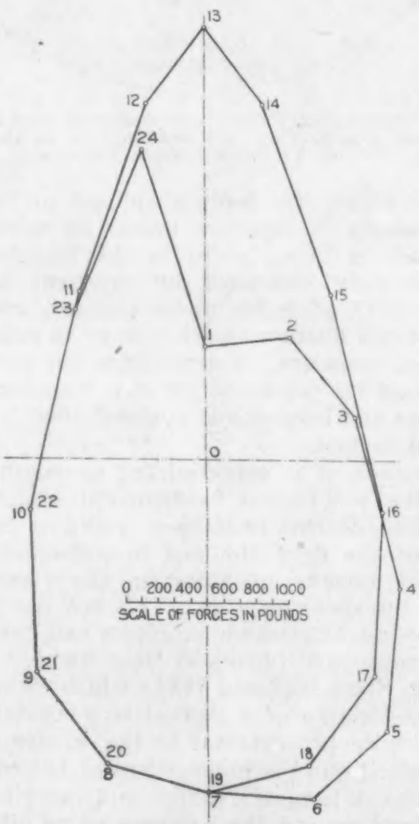


Fig. 2.—Combined Centrifugal, Gas and Inertia Forces Acting on Crankpin and Six-Cylinder Engine

It is difficult to neutralize by balance weights the effect on the crankpin of the forces shown in Figs. 2 and 6. The reason is that the centrifugal forces involved are due to a mass performing a relative motion. That is to say, the rotating mass of the connecting-rod is not rotating truly about its own center but turns relative to another mass, which turns about a center of its own.

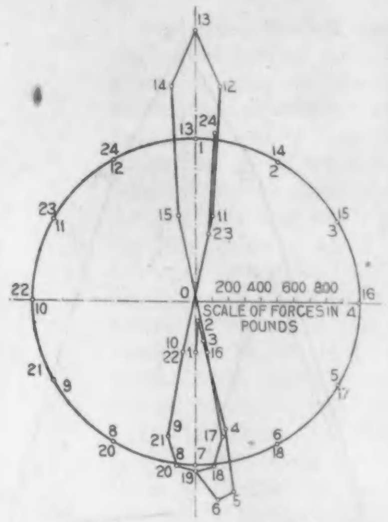


Fig. 3.—Centrifugal Forces and Combined Gas and Inertia Forces Due to One Cylinder Acting on Crankpin of Twelve-Cylinder Engine

Balance weights in order to be entirely effective under such circumstances would in turn have to perform relative motions. This introduces extra friction and complication. Balance weights for this effect are quite feasible, however, for six-cylinder engines, but they are almost an impossibility for twelves. The diagrams reveal the fact that the forces are smallest in a horizontal direction. This suggests that the oil holes in the crankpin should be placed at right angles to the radial lines through its center. The preferable direction would be opposite to that of rotation. To prevent the oil from escaping a labyrinth should be cut in the bushing bearing-surface, where the forces are a minimum.

A glance at Figs. 2 and 6 shows that the difference in the loads acting on the crankpin of either engine is not marked. The maximum load in the case of the twelve is 4040 lb., in the case of the six it is 4795 lb. The difference between the two is 18¾ per cent. These loads increase approximately as the square of the speed. If then the twelve-cylinder engine runs at 2940 r.p.m. it is subject to the same maximum load as is the six when running at 2700 r.p.m. Mention is made of this because we generally find in practice that a car with a twelve-cylinder engine is geared so that the engine runs at slightly higher speed than a six-cylinder engine would be made to run.

The life of a crankshaft bearing depends largely on the magnitude of the mean pressure resulting from the various loads acting during one complete cycle. We find that this is 15 per cent smaller with the six than with the twelve. It is an axiom in bearing design that a certain permissible load per unit of bearing surface should not be exceeded. Nevertheless we shall not content ourselves with speaking of maximum or mean loads exclusively. This seems to be a mistake which is com-

mitted by altogether too many engineers who endeavor to design high-speed engine bearings with a certain specific load as their only guide.

Designers also should not loose sight of the fact that intermittent loads, such as we have to deal with in high-speed internal combustion engines, affect bearings differently than does a steady load. It is well understood that a load acting continually in one direction is likely to

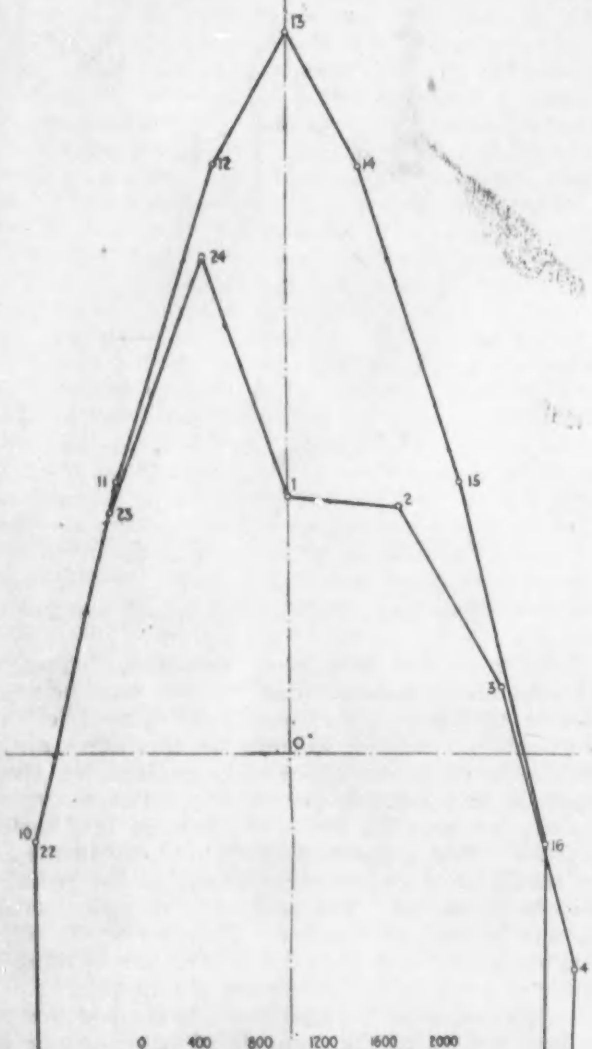


FIG. 4.—COMBINED CENTRIFUGAL, GAS AND INERTIA FORCES DUE TO ONE CYLINDER ACTING ON CRANKPIN OF TWELVE-CYLINDER ENGINE

cause lubrication difficulties. To what extent a bearing will behave well under the effect of a steady load is shown by an experiment* made by Professor Goodman, who states that he has had a journal running for weeks with a surface velocity of 4 ft. per second under a steady load of 2 tons (4480 lb.) per sq. in., the journal being kept at a temperature of 110 deg. fahr. by a stream of water forced through it. It is evident that bearing loads of this magnitude are hardly permissible under

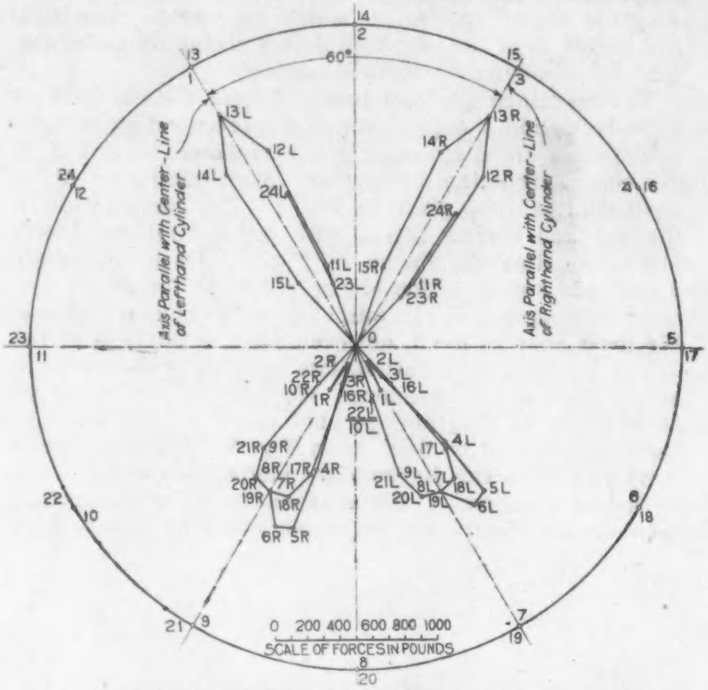


FIG. 5.—CENTRIFUGAL FORCES AND COMBINED GAS AND INERTIA FORCES DUE TO TWO CYLINDERS ACTING ON CRANKPIN OF TWELVE-CYLINDER ENGINE

conditions where the load is subject to frequent and abrupt changes in direction unless an unusual amount of attention is being given to the maintenance of a certain running clearance by frequent adjustments. Therefore it is advisable under ordinary circumstances either to avoid fluctuations in load or to reduce the specific bearing pressure. For instance, the maximum permissible load on crankpins of slow running stationary gas engines and locomotives is about 1500 lb. per sq. in. of bearing surface.

Furthermore, it is essential for an engineer to bear in mind the well-known fundamental empirical law of fluid motion, that the resistance to sliding is due to the shearing of the fluid film and is consequently a function of the velocity of shearing, the viscosity of the fluid, and the shearing area. This law has proved useful for solving lubrication problems and conforms with the well known experiments by Beauchamp Tower (Proc. Inst. Mech. Eng., 1883 and 1884) which showed that the frictional resistance of a journal at a constant temperature is directly proportional to the square root of the rubbing velocity and is independent of the total load.

The different laws of friction and carrying power so far mentioned assume the presence of an oil film of not less than a certain thickness between the journal and the bearing. Without this no bearing can be safe against undue abrasion. To maintain this much desired oil film the designer should as far as possible protect bearings from unequal pressure distribution, from abrupt changes in the direction of these pressures, and from an undue rise of temperature.

The pressure distribution, which is in most cases more or less imperfect, depends on the design of the crankshaft. It will be discussed more in particular later on in this paper, together with other features inherent to different designs. The character of pressures can be determined by means of diagrams. From

*Unwin, Elements of Machine Design, Part I, page 243.

these diagrams we may derive the mean bearing pressure, which, when multiplied by the circumferential velocity of the journal and the coefficient of friction, represents the work expended in friction.

The rise in temperature may be expressed as a function of the work expended in friction, if we limit ourselves to conditions where the radiating surface of the bearing and the feed of oil are the same.

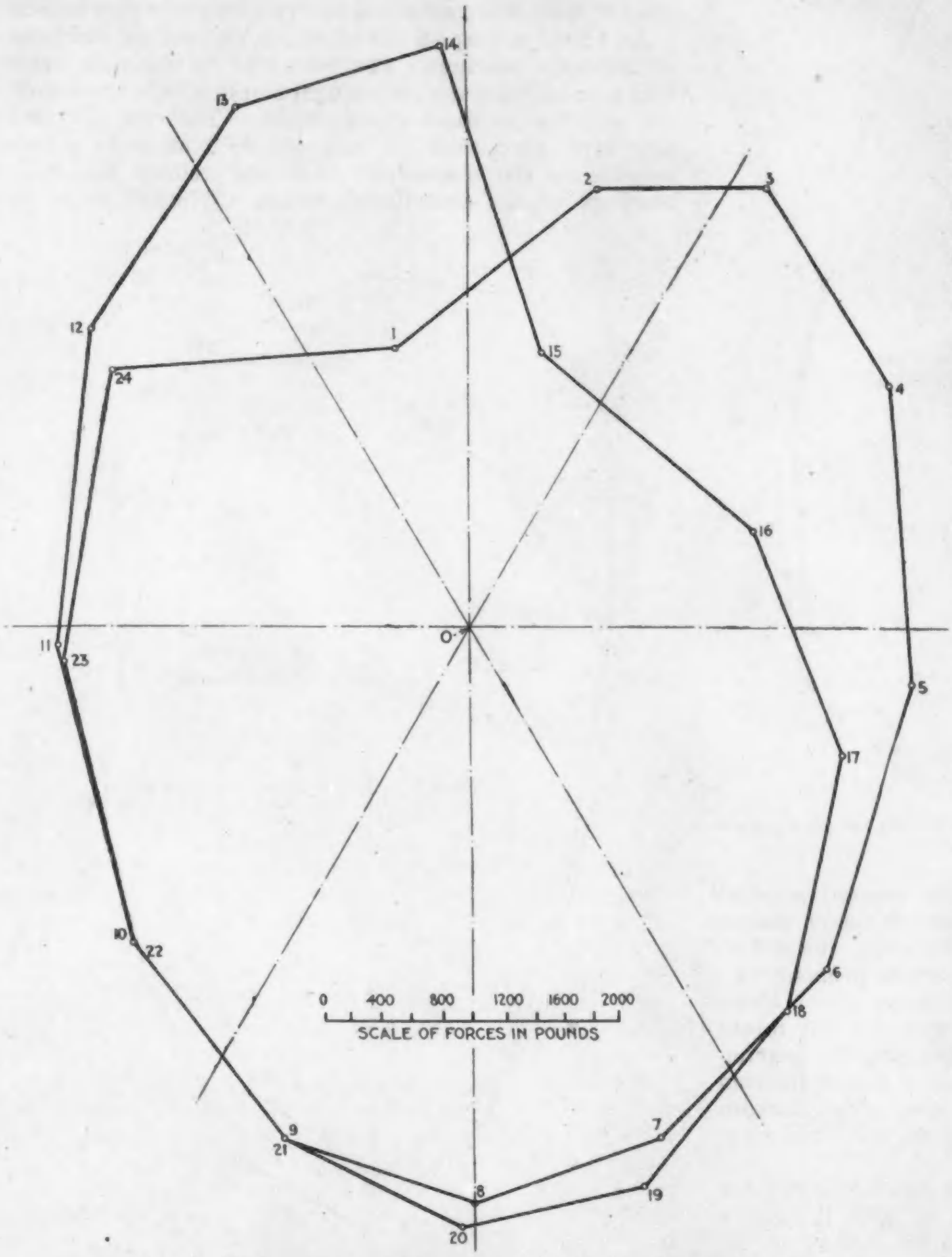


FIG. 6.—COMBINED CENTRIFUGAL, GAS AND INERTIA FORCES DUE TO TWO CYLINDERS ACTING ON CRANKPIN OF TWELVE-CYLINDER ENGINE

The frictional work per square inch of bearing surface is mathematically expressed by:

$$w = \mu \frac{P}{dL} \times \frac{d\pi N}{12 \times 60} = \mu pv \quad (1)$$

In this equation

w = work expended in friction per second and per square inch of bearing surface.

μ = coefficient of friction.

P = total bearing load, pounds.

p = specific bearing load, pounds per square inch.

d = diameter of shaft, inches.

L = length of bearing, inches.

N = speed of shaft, revolutions per minute.

v = circumferential velocity of shaft, feet per second.

From (1) it follows that

$$pv = \frac{PN}{229L} \quad (2)$$

According to data gathered from well performing and durable engines it may be stated that the value (pv) should not exceed 17,000 ft-lb. per sec. This value is far in excess of other similar values. Güldner states that in case of stationary gas engines the maximum limiting value of (pv) based on experience is about 1500 ft-lb. per sec. for bearings lined with white metal. From this it is evident that values of 17,000 ft-lb. per sec. are permissible only in cases where forced lubrication is used.

In this connection the author suggests that some action by the S. A. E. Standards Committee along the line of determining (pv) values for different lubricating systems not only would be desirable but also would be, like all other work of standardization, highly appreciated.

To apply this pressure-velocity criterion to the two engines under consideration we must determine the mean pressure of a complete cycle from Figs. 2 and 4. These are 2870 and 1650 lb. for the six and twelve respectively. Assuming a crankpin diameter of 2⅛ in. for either engine, we obtain, at 2700 r.p.m., a rubbing velocity of

$$V = \frac{2\tfrac{1}{8}\pi 2700}{60 \times 12} = 25.02 \text{ ft. per sec.} \quad (3)$$

With a crankpin length of 2 in. we obtain, in the case of the six

$$pv = \frac{2870 \times 2700}{229 \times 2} = 16{,}900 \text{ ft-lb. per sec.} \quad (4)$$

With a crankpin length of 1 5/32 in. we obtain, in the case of the twelve

$$pv = \frac{1650 \times 2700}{229 \times 1\ 5/32} = 16{,}825 \text{ ft-lb. per sec.} \quad (5)$$

The total crankpin length of the twelve, if the connecting-rods are arranged side by side, should therefore be 2 5/16 in. This is about 15 per cent more than the corresponding length of the six. With equal crankpin diameters for both engines, the crankpin lengths must be proportional to the load. In order to verify this the mean total load acting on the crankpin of a twelve has been determined from the diagram in Fig. 6. As expected, it is 3300 lb., or 15 per cent more than the total load acting on the crankpin of the six.

This and all further comparisons between the six and twelve-cylinder engines are based on the assumption that both engines are running at the same speed. But,

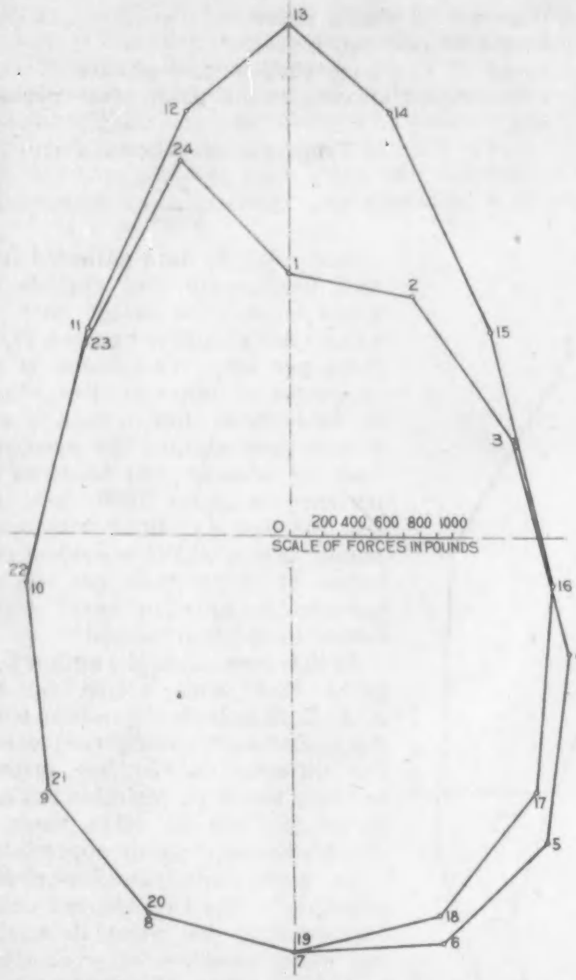


FIG. 7.—LOADS ON MAIN BEARINGS NOS. I AND VII OF CRANKSHAFT WITHOUT BALANCE WEIGHTS

as has been emphasized before, it is general practice to run a twelve-cylinder engine somewhat faster than a six. If this were taken into consideration, the difference between both engines would be more pronounced.

Before we accept the crankpin lengths given above as representing the final values, we will ease our minds with regard to the magnitude of the specific bearing pressure. In case of the six we have a maximum load of 4795 lb. The projected bearing area of a crankpin $2\frac{1}{8}$ in. diameter and 2 in. long is $4\frac{1}{4}$ sq. in. This gives 1125 lb. as the specific pressure.

In the case of the twelve we have a maximum load for each cylinder (taken from Fig. 4) of 2660 lb. and a projected bearing area of $2\frac{1}{8} \times 1\ 5/32 = 2.46$ sq. in. This necessitates a specific bearing pressure of 1080 lb. The difference between both values is only 4.1 per cent. Both are of such magnitude as to be just about permissible. If the engines are to be used for automobile propulsion, then we may bear in mind that maximum speed is generally not maintained for any great length of time. The loads above given would represent, then, the exception and not the rule.

Automobile engines are frequently subject, however, to hard usage when long hills are climbed on high gear. Under such conditions the explosive pressures alone determine the loads on the bearings, because the speed of the engine is generally so low that the inertia and centrifugal forces are negligible. Assuming an explosion pressure of 380 lb. per sq. in. for both engines, we obtain total explosive loads of 4200 and 2690 lb. for the six and the twelve respectively. In the first case we obtain, then, a specific crankpin pressure of 4200/4.25, or 990 lb., while in the second we obtain 2690/2.46, or 1095 lb. The difference between both engines is here 10.6 per cent in favor of the six. The loads of the two engines due to explosive pressure alone are somewhat smaller than those obtained before at high engine speeds.

All forces acting on the crankpin necessitate reactions on the main bearings. The total load on the main bearings also includes the centrifugal forces due to the crankpin and the adjacent crank-cheeks. Theoretically, and now even practically, it is a simple matter to attach weights to the crankshaft that will relieve the main bearings of the centrifugal forces. Whether it is an

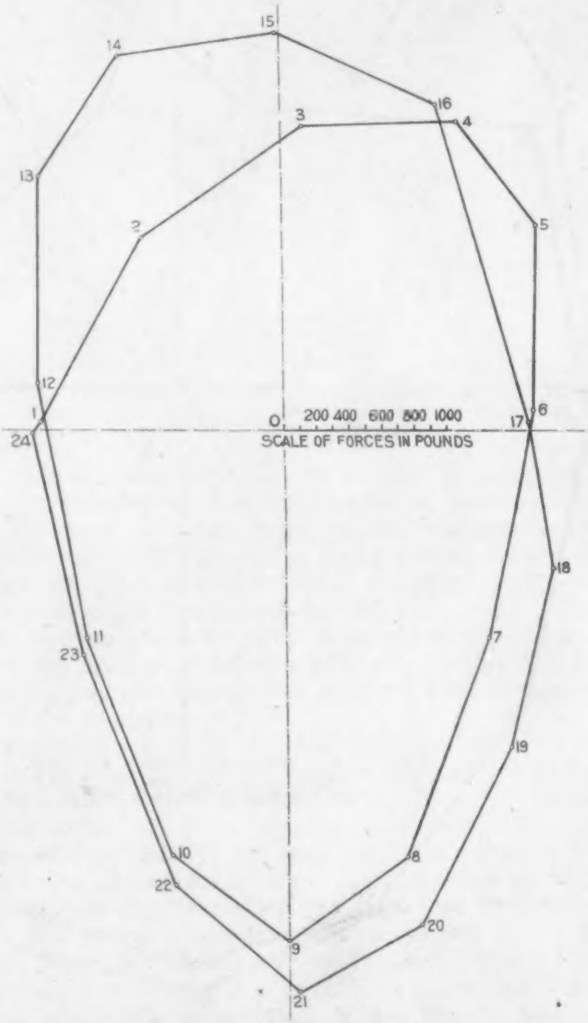


FIG. 8.—LOADS ON MAIN BEARINGS II, III, V AND VI OF CRANKSHAFT WITHOUT BALANCE WEIGHTS

advantage to do so we shall presently investigate by means of diagrams.

The forces that we have to deal with at first are those relating to the six-cylinder engine and resolved into components in a manner as determined for a crankshaft of the seven-bearing type.

We are now concerned with two groups of diagrams: First, main-bearing load for a crankshaft without balance weights. Fig. 7, loads on main bearings I and VII (counting from front of engine); Fig. 8, loads on II, III, V and VI; and Fig. 9, load on IV.

Second, main-bearing load for a crankshaft with balance weights. Fig. 10, loads on main bearings I and

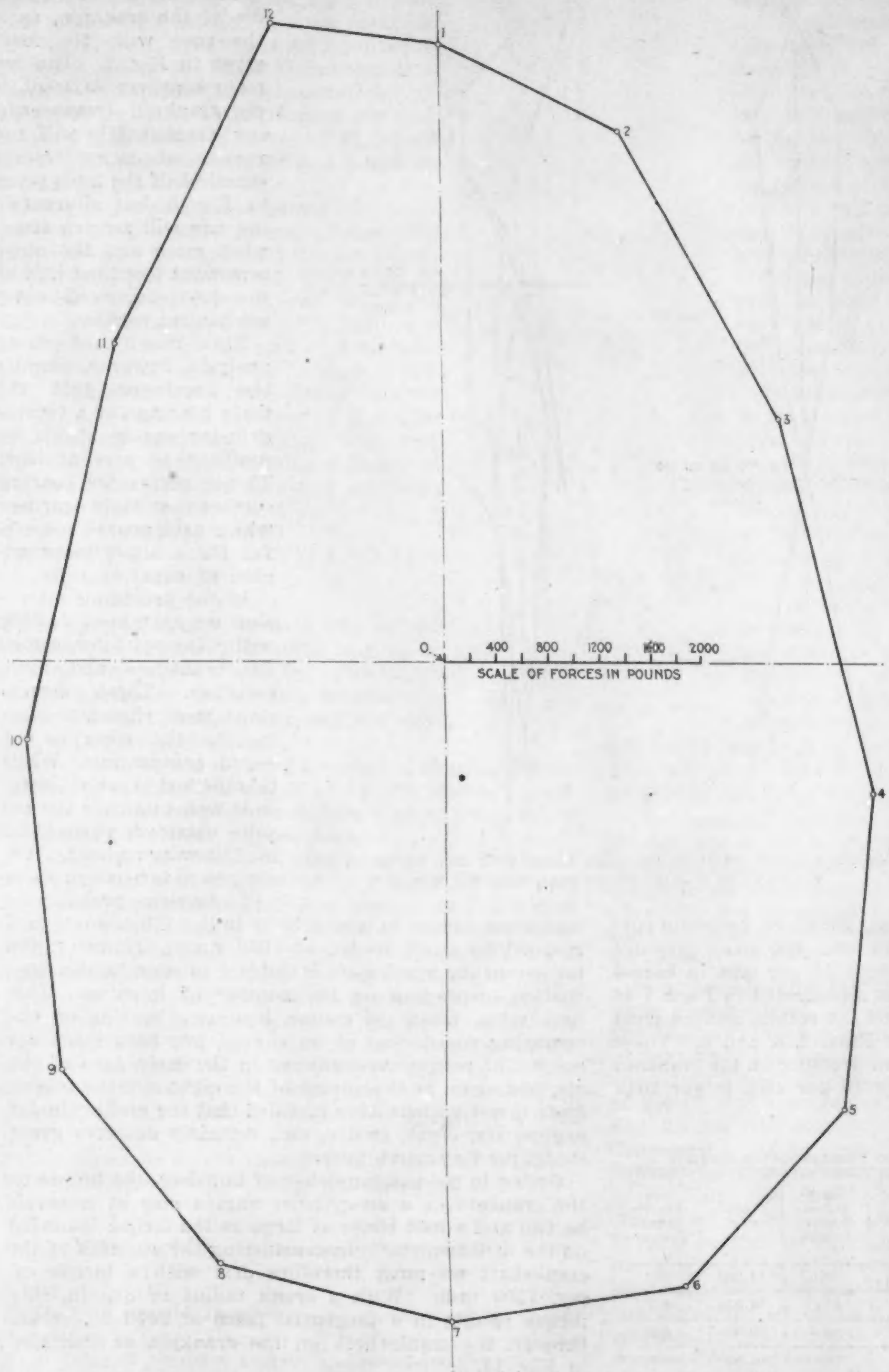


FIG. 9.—LOADS ON MAIN BEARINGS IV OF CRANKSHAFT WITHOUT BALANCE WEIGHTS

VII; Fig. 11, loads on II, III, V and VI; and Fig. 12, load on IV.

It is evident from the scale of the diagrams that the balance weights act to reduce considerably the loads on the bearings, but, as already stated, magnitude is not the last word to be said about loads. Sudden fluctuations in the direction of the load are equally, if not more, detrimental to a bearing than the mere magnitude of the loads. Quick changes in the direction of a force acting on a mass are always accompanied by inertia effects. We must expect, therefore, that the journals carrying loads as shown in Figs. 10 to 12 will develop an undesired reciprocating or rocking action. Figs. 7 to 9, however, represent comparatively steady loads. The journals carrying these loads will creep around on the bearing surface, an action in principle like that involved when a planetary gear rolls within an internal gear. This facilitates lubrication, because the lubricant, while adhering to the metal surfaces, is continually wedged in between the two bounding surfaces. From this we see that beyond pounds of load per bearing there is, so far, nothing to say in favor of balance weights.

The length of the bearings necessary to carry the respective loads safely can be determined by the formula

$$pv = 17{,}000 \text{ ft-lb. per sec.} \qquad (6)$$

With a main bearing diameter of 2⅛ in. we obtain for 2700 r.p.m. of the engine a circumferential velocity of

$$v = 25.02 \text{ ft. per sec.} \qquad (7)$$

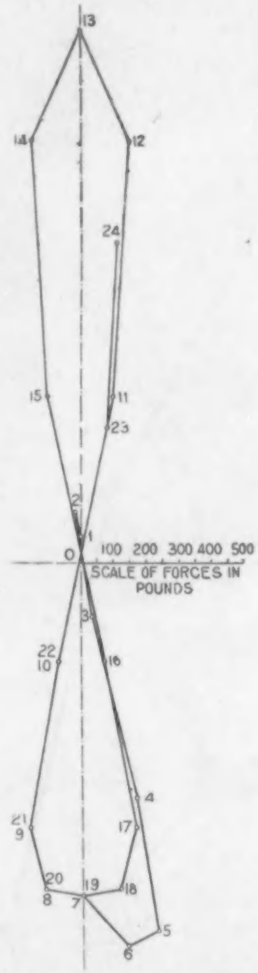
The mean loads on the bearings, as obtained from the diagrams, are given in Table II, together with the necessary bearing lengths, the values of (pv) and the specific bearing pressures.

In case of bearings I and VII, a liberal amount should be added to the length of the bearing to take care of the loads due to the timing gears and the flywheel, and at least ¼ in. should be added to every bearing to allow for fillets. But in spite of this we find that the bearing lengths for the balanced type are entirely too short to hold the requisite oil pressure. If they are lengthened so that they are in conformity with this practical consideration we will obtain bearings for a crankshaft with balance weights about as long as those for a crankshaft without balance weights.

Apart from these analytical considerations it has now

become an established fact that smooth running, life and power of a well-designed engine with a seven-bearing shaft cannot be improved by the addition of balance weights. This is true in spite of the fact that any shaft with balance weights will perform much better on any balancing machine than will its prototype without balance weights. This paradoxical result is easily explained if we bear in mind that a shaft, when running in a balancing machine, is not subject to the sudden impulses which are a necessary evil inherent to the reciprocating engine. It seems that the best method to make these impulses harmless is to smooth them out by means of the centrifugal forces, which, as we know, are available free of charge.

It remains now to determine the loads on the main bearings for the twelve-cylinder engine in a manner similar to that which we adhered to in the case of the six. However, since there is not the slightest difference in the procedure, it is permissible to draw conclusions from former results. We must, therefore, reconcile ourselves with the fact that in all cases the mean pressure of a complete cycle will be about 15 per cent in excess of the corresponding pressures represented in Figs. 7 to 12. This conclusion is based on the results derived from the force diagrams shown in Figs. 2, 4 and 6. These diagrams showed that the mean pressure on the crankpin of a twelve-cylinder engine is 15 per cent larger than that on the crankpin of a six.



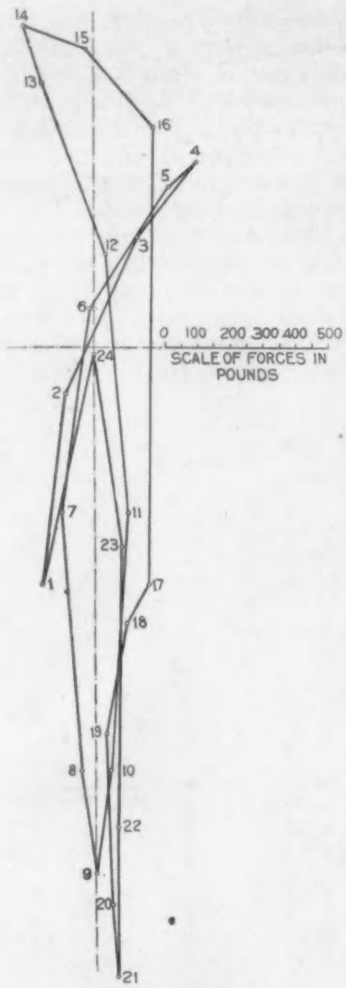


FIG. 10.—LOADS ON MAIN BEARINGS I AND VII. FIG. 11, ON II, III, V AND VI OF A CRANKSHAFT WITH BALANCE WEIGHTS

TABLE II—DATA FOR BALANCED AND UNBALANCED CRANKSHAFTS

Bearing Number	Type of Crankshaft	Mean Load	Theoretical Bearing Length	Value of pv	Mean Specific Bearing Pressure
I, VII	Balanced	774	9/16	16,200	648
	Unbalanced	2180	1 13/16	16,425	657
II, III, V, VI	Balanced	839	3/4	15,800	633
	Unbalanced	2190	1 13/16	16,500	660
IV	Balanced	1520	1 1/16	16,725	670
	Unbalanced	4350	3	17,040	682

In the case of a twelve with two connecting-rods mounted side by side on one crankpin the distribution of load over the whole length of the crankpin is not uniform, because the loads on the two connecting-rods do not at every instant act with equal intensity. The point of application of the resulting loads given in Fig. 6 is therefore not in the middle of the crankpin, as is the case with the loads given in Fig. 2. The two main bearings adjacent to the crankpin (seven-bearing crankshaft) will not receive at every instant exactly half the loads given in Fig. 6, but alternately the one will receive somewhat more and the other somewhat less than half of the total for well-known mechanical reasons.

This rough-and-ready analysis, however, permits the conclusion that the main bearings of a twelve-cylinder engine should be designed to give at least 15 per cent more bearing surface than main bearings which have proved successful for a six-cylinder engine of equal capacity.

In the preceding discussion we have been dealing with various dimensions for crankpins and main bearings. These dimensions were chosen according to the dictation of sound engineering. While this method is satisfactory, it is well to verify the results obtained, perhaps in the following manner. Both engines so far spoken about will develop probably a maximum torque of about 3000 in-lb. This would correspond to about 48 hp. at 1000 r.p.m. However, the torque on the crankshaft is subject to considerable fluctuation, depending on the number of impulses. This fluctuation, which, of course, has some bearing on the operating smoothness of an engine, has been made the subject of many investigations in the early days of the six, and again at the advent of the eight and the twelve. Such investigations have revealed that the multi-cylinder engine, six, eight, twelve, etc., certainly deserves great credit for its smooth torque.

Owing to the small number of impulses, the torque on the crankpin of a six-cylinder engine may at intervals be two and a half times as large as the torque indicated on the dynamometer. In considering the strength of the crankshaft we must therefore deal with a torque of, say, 7500 in-lb. With a crank radius of $3\frac{1}{8}$ in. this torque results in a tangential force of 2400 lb., acting through the crank-cheek on the crankpin as indicated in Fig. 13.

If we at first assume the crank-cheeks as being infinitely strong, we can consider the crankpin as a cantilever. With a crankpin length of 2 in., plus half the width of the cheek, the total length of the cantilever will be about $2\frac{1}{2}$ in. The bending moment is, consequently, $2400 \times 2\frac{1}{2} = 6000$ in-lb. The moment of resistance to bending of a $2\frac{1}{8}$-in. diameter cylinder with a 1-in. hole is 0.896 in.[3] With an elastic limit of 110,000 lb. per sq. in. (chrome nickel steel) we obtain from these

data 16.4 as the factor of safety. Crankpins are further subject to some shearing and bending due to the load acting directly on them, but in the above calculation this has not been taken into consideration. If we allow for these extra stresses we may obtain a final factor of safety of 12, which is not too much for so important a part as a crankshaft.

After this we may now assume the crankpin to be infinitely strong. From this point of view we must expect the crankcheeks to deflect in a manner as shown in Fig. 13. The twisting moment to be resisted by the cheeks evidently is $2400 \times 3 = 7200$ in-lb. The moment of resistance to torsion of a rectangular section is 2/9 b^2h. The permissible fiber stress in case of twist is about 75 per cent of that permissible for bending. Taking this into consideration, and maintaining a factor of safety of 12, gives the following equation:

$$7200 = 2 \times \frac{0.75 \times 110{,}000}{12} \times \frac{2}{9}\, b^2h \qquad (8)$$

From this we obtain for $h = 2\frac{3}{4}$ in. the thickness of the cheek as 0.925 in.; or, to give an even figure, 15/16 in. This small special allowance is desirable because the crank-cheeks, like the crankpins, are subject to compound stresses.

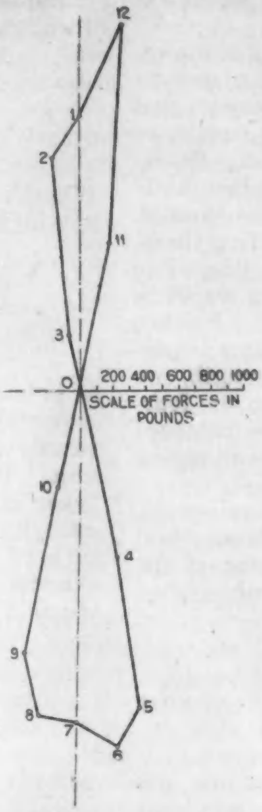


FIG. 12.—LOADS ON IV

In this connection it may be remarked that the crankcheeks, as a rule, are found to be the weakest parts. Fig. 13 and the calculations explain why so many shafts break along the lines marked *a-b-c*.

In case of the twelve-cylinder engine, the maximum torque on the crankpin will be only about 50 per cent more than that indicated on the dynamometer. We shall therefore have to deal with a torque of about 4500 in-lb. With a crank radius of $2\frac{1}{2}$ in. we derive from this torque a tangential force of 1800 lb. acting through the crankcheeks on the crankpin. With a crankpin length of 2 5/16 in., plus half the width of the cheek, we have a total length of $2\frac{3}{4}$ in. The bending moment on the crankpin is, therefore, $1800 \times 2\frac{3}{4} = 4950$ in-lb. The factor of safety of 20 is derived from this. The twisting moment in the crank-cheeks is $1800 \times 3\ 3/16 = 5740$ in-lb.

The thickness of the cheeks with a factor of safety of 12 we derive, as before, from the equation:

$$5740 = 2 \times \frac{0.75 \times 110{,}000}{12} \times \frac{2}{9}\, b^2h \qquad (9)$$

From this we obtain a cheek thickness of 0.83 in., or say ⅞ in.

In order to compare a three and seven-bearing shaft it must, first of all, be observed that the distance between the centers of the two main bearings is about two and a half times as much in the former shaft as in the latter. The transverse deflection of a straight shaft increases at the cube of the distance between the supports. It is evident, therefore, that, if other conditions are the same, a three-bearing shaft will deflect up to $(2\frac{1}{2})^3$; that is, nearly sixteen times as much as a seven-bearing shaft.

It is hardly necessary to point out that excessive deflections are certainly not condusive to the operating smoothness of an engine. Not only that, but even the durability of the bearings is impaired, because a deflected shaft will not permit uniform pressure distribution in the bearing. Any eccentricity of the loading relatively to the middle of the bearing will create a tendency to drive out the oil at one end. This is the reason why bearings that swivel so as to accommodate themselves to any inclination of the journal on account of bending of the shaft are found to be of great advantage. However, as such bearings cannot be applied very well to crankshafts, it is advisable to design crankshafts so that their deflections approach a minimum.

The deflection of a shaft varies inversely as the moment of inertia of its weakest section. In order, then, to hold a three-bearing shaft within the same limit of transverse deflection as may be obtained with a seven-bearing shaft the crankpin diameters of both shafts must be proportioned in the relation of $\sqrt[4]{16}$ to 1, which is as 2 to 1. This necessitates a crankpin diameter of $4\frac{1}{4}$ in. for a three-bearing shaft designed to conform to our premises. For so small an engine as here under consideration this diameter is, of course, prohibitive. At the same time, it is almost prohibitive to use a seven-bearing shaft for a twelve-cylinder automobile engine on account of the excessive length. The only alternative left for the designer of such engines is to sacrifice rigidity.

The torsional deflection of a crankshaft is directly proportional to the torque moment. In a seven bearing crankshaft a torque moment of the magnitude $M = T \times r$ occurs in the main bearings only. This torque is determined by the tangential force (T) acting on crankpin and the crank radius (r), which is one-half the stroke of the engine.

In a three-bearing crankshaft, a similar but more intense torque occurs, not only in the main bearings but also in the crankpins, as is illustrated in Fig. 14. The momentum of the torque in this case is determined by T and by the shortest distance between T and the center of the twisted crankpin, which is denoted by R. From Fig. 15 we find that $R = r + r \sin 30$ or $R = 1.5\ r$. Consequently, in this case, $M = T \times 1.5\ r$. This permits us to draw the conclusion that the torque moments or torsional deflections of a three and seven-bearing crankshaft stand to each other in the relation of 1.5 to 1. It must further be mentioned that the twist in a crankpin is a more serious matter than the twist in the main bearings. We must consider that the only way to reduce the vibrations set up by a twist in a crankpin is by an increase in its diameter. The deflections in the main bearings may, however, be minimized by vibration dampers.

The same line of reasoning which we have established in connection with the three-bearing shaft must be followed in investigating a four-bearing, six-throw shaft. The distance between two bearings is about 1.75 times as great as in the case of a seven-bearing shaft, and consequently the transverse deflection is about five times larger. With regard to the torque in the crankpins, the same figures as before established apply, except that in

this case a smaller number of crankpins are subject to twist.

As excessive transverse deflections must be detrimental to the bearings as well as to the operating smoothness of the engine, it is quite reasonable to expect that balance weights will be an advantage for the latter two types of crankshafts, which are inherently weak. Seven-bearing crankshafts, when well designed, are inherently strong enough so that they cannot be improved through the addition of balance weights. We can predict, therefore, that the use of balance weights will be limited to shafts with a smaller number of bearings than would be desirable from the viewpoint of strength. Balance weights are like the flywheel, the symbol of some imperfection. If we compare shafts of equal strength, we will further find that the weight of a three or four-bearing, six-throw crankshaft that is properly balanced will by no means be less than that of a seven-bearing shaft.

The total piston displacements of different engines designed with a constant stroke-bore ratio are proportional to the cube of the cylinder bore. For instance, if the bore of an engine is b, and its stroke is $1.667b$, the piston displacement of this engine per cylinder is

$$\frac{b^2\pi}{4} \times 1.677b = 1.309b \qquad (10)$$

The explosive impulses of different engines are proportional to the square of the cylinder bore, providing that the same compression is used throughout. Denoting the bore of a six-cylinder engine with b_6, and that of a twelve-cylinder engine with b_{12}, we find for two engines of equal total piston displacement the following relation:

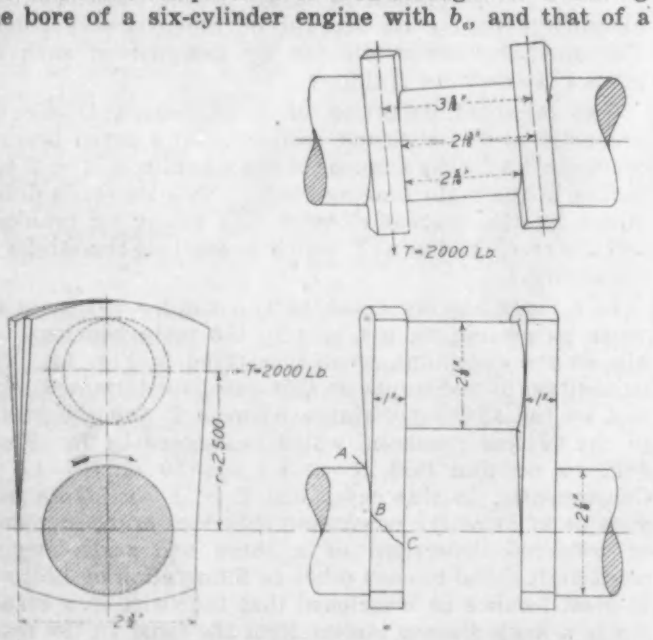


FIG. 13.—PART OF CRANKSHAFT ILLUSTRATING DEFLECTION OF CRANK-CHEEKS

$$6 \times 1.309 \times b_6^3 = 12 \times 1.309 \times b_{12}^3 \qquad (11)$$

From this follows

$$b_6 = \sqrt[3]{2} \times b_{12} \qquad (12)$$

The explosive impulse E of an engine is proportional to the square of the cylinder bore. Between the explosive impulses of a six and twelve-cylinder engine exists, therefore, the following relation:

$$\frac{E_6}{E_{12}} = \frac{b_6^2}{b_{12}^2} \qquad (13)$$

When substituting for b_6 the value given in (13), we obtain

$$\frac{E_6}{E_{12}} = \frac{(\sqrt[3]{2})^2 \times b_{12}^2}{b_{12}^2} = \frac{(\sqrt[3]{2})^2}{1} \qquad (14)$$

In practice we invariably find that the small-bore engine is working under somewhat higher compression. This results in a higher explosive force per unit of piston area. To give an example, we may assume, for the two types of engines to be compared, that the large-bore, six-cylinder engine may work with a compression pressure of 85 lb. per sq. in., and the small-bore twelve-cylinder engine with one of 90 lb. per sq. in. Substituting this in the above given relation, we obtain

$$\frac{E_6}{E_{12}} = \frac{85}{90} \times \frac{(\sqrt[3]{2})^2}{1} = 1.5 \text{ to } 1 \qquad (15)$$

From this we learn that for a certain standard of engineering the explosive impulse of a six-cylinder engine is about 1.5 times as large as that of a twelve-cylinder engine of equal total piston displacement.

In conclusion, a few words may be said about lubrication, although this can be considered a problem all by itself. To obtain absolutely satisfactory conditions, the oil delivery to the bearings must be in direct proportion to the work converted into heat by the bearings. We should lay out a series of diagrams, as previously discussed, for different engine speeds and for different power output. The values of (pv) obtained from the various diagrams would give us a clear picture of how the oil delivery should be regulated. Scientific oiling would eliminate scraper rings, and thus permit lighter pistons. It would further eliminate sooted spark-plugs, carbonization, preignition, and would permit higher compression.

THE DISCUSSION

CHAIRMAN DAVID FERGUSSON:—Mr. Burkhardt's paper to my mind, brings out several facts: First, that with twelve and six-cylinder engines of the same cylinder volume, the crankshaft of the twelve will weigh considerably more than that of the six, if made in the usual manner for passenger automobiles with three-journal bearings; moreover it cannot be expected to have the same freedom from vibration.

Second, in regard to balance weights. Not long ago great publicity was given by a prominent passenger automobile manufacturer to a test conducted of an engine with and without balance weights. The results were altogether in favor of the latter. It must not be concluded however that because of this, balance weights are necessary or even desirable. Had this manufacturer tested an engine with a crankshaft of ¼ in. larger diameter and adequate bearings, he might possibly have had just as good results with a considerable saving in weight; or had he put all the extra weight of the balance

weights into the diameter and stiffness of his crankshaft, he might possibly have obtained even better results without balance weights, especially if he had used a seven-bearing crankshaft instead of the design he adopted, which had fewer bearings.

Third. There is no adequate formula to determine the proper diameter of a crankshaft. Mr. Burkhardt as-

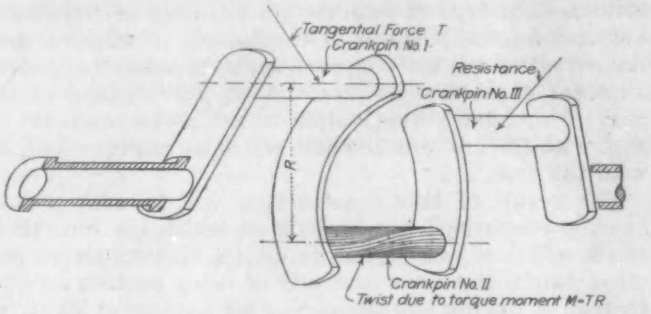


FIG. 14.—PART OF CRANKSHAFT ILLUSTRATING TORQUE IN CRANKPIN IN CASE OF THREE AND FOUR-BEARING SIX-THROW CRANKSHAFTS

sumed $2\frac{1}{8}$ in. for the shafts of the two engines he considered, probably because of his knowledge that certain seven-bearing six-cylinder engines of similar cylinder volume were giving satisfactory results with such a diameter of shaft. Taking resistance to deflection due to the pressure of explosion or inertia effect as being the determining factor, he shows clearly that the three-bearing twelve-cylinder crankshaft required will be double the diameter of the six-cylinder seven-bearing shaft, giving the enormous size of $4\frac{1}{4}$ in. diameter.

It is almost impossible to arrive at the correct diameter of automobile crankshafts in order to insure freedom from engine vibration, except by obtaining these sizes from experience, or, lacking this, from the prevailing practice of the successful manufacturer of similarly designed engines. Due regard must be given as to whether the engine is a four-cylinder with a two, three, four or five-bearing shaft; a six-cylinder with a three, four or seven-bearing shaft; an eight-cylinder with a three-bearing shaft; or a twelve-cylinder with a three, four or seven-bearing shaft.

There is a tendency to use larger diameters than in the past in order to eliminate vibration. The following rule of thumb gives a fairly good comparison with most of the successful medium-speed car and truck engines in use at present, having stroke-bore ratios of from 1.3 to 1.6, and having reciprocating parts of medium weight.

In a four-cylinder, three-bearing crankshaft engine, the diameter of crank journals and pins is made 0.5 of the cylinder diameter.

In a six-cylinder seven-bearing crankshaft engine, the diameter of the journals is made from 0.55 to 0.6 of the cylinder diameter.

In an eight-cylinder three-bearing crankshaft engine, the diameter of the journals and pins is made from 0.65 to 0.7 of the cylinder diameter.

In a twelve-cylinder three-bearing crankshaft engine, the diameter of the journals and pins is made from 0.75 to 0.8 of the cylinder diameter.

These proportions do not apply to airplane engines, the crankshafts of which are made much smaller in diameter.

O. M. BURKHARDT:—Mr. Fergusson's characteristic remarks constitute a comparison of results obtained by analysis with results obtained from practical experience. It is true I have proceeded deductively rather than inductively. I have taken journal diameters that have been found successful and have derived from them the factors of safety and certain specific values. Therefore these values, derived from experience, will be found useful until the present prevailing practice is found unsatisfactory. It will then become necessary to establish new axioms such as perhaps a maximum permissible deflection.

CHARLES M. MANLY:—I question the statement that the larger steady loads, such as encountered in crankshafts without balance weights, are more desirable than the smaller fluctuating loads acting on the main bearings of crankshafts with balance weights. My experience with small fluctuating loads has shown that it is not difficult to find bearings to take care of them. Furthermore in the case of crankshafts without balance weights the extra heat generated due to the larger percentage of mean load may become objectionable.

O. M. BURKHARDT:—It is a well-known fact that a bearing carrying a load acting continually in one direction is likely to cause lubrication difficulties. However, this phenomenon need not be feared in the case of a crankshaft without balance weights because the load, while steady with regard to magnitude, continually changes its direction and thus conforms to the requirements essential for satisfactory lubrication. The very gradual rate of change in direction is certainly better than an abrupt change.

With regard to the heat generated due to the larger mean pressure I must repeat that the specific value of *pv* should be kept constant for all bearings if other things are the same.

E. W. HARRIS:—It seems to be that Mr. Burkhardt dismissed the question of three and four-bearing crankshafts in an altogether unduly abrupt manner. In view of the distinct tendency at present to make smaller and smaller engines operating at higher speeds, we must consider the possibilities of such crankshafts.

I refer particularly to engines for passenger cars. There is little doubt that in the near future we shall be employing small cylinder diameters and that in a sensibly designed engine it will be impossible to provide for

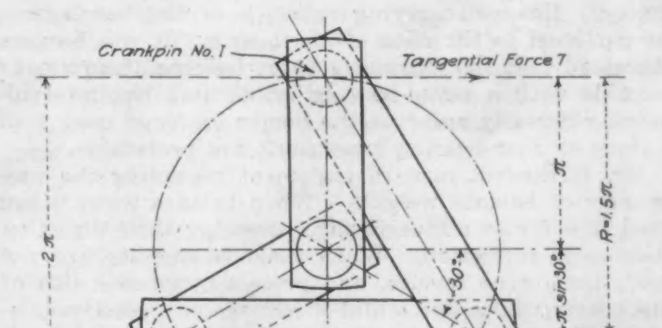


FIG. 15.—PART OF CRANKSHAFT SHOWING MAXIMUM LEVERAGE IN CASE OF THREE AND FOUR-BEARING SIX-THROW CRANKSHAFTS

efficient intermediate bearings between each pair of cylinders.

I do not agree with Mr. Burkhardt with regard to three and four-bearing crankshafts being inherently weak. In a properly designed and inherently balanced three or four-bearing crankshaft the intermediate webs replacing journal bearings are always much wider and deeper than the webs that come next to the journal bear-

ings. This in itself takes care of the greater stresses imposed on these webs, and, if properly designed, gives us a perfectly satisfactory crankshaft.

The problem of lubrication is undoubtedly one that presents increasing difficulties as time goes on, especially as we increase our specific bearing pressures and increase our surface speed.

We shall probably be compelled to consider seriously the advisability of supporting our crankshafts in some form of anti-friction bearing, which will not require the attention for lubrication demanded by the present accepted standard type of crankshaft bearing.

I refer particularly to the non-adjustable roller type of bearing, which to my knowledge has given excellent results as a crankshaft bearing.

Value of Intermediate Webs

O. M. BURKHARDT:—Mr. Harris points out that the intermediate webs replacing journal bearings are always strong enough to take care of the greater stresses imposed on them. Since I have not investigated crankcheeks of three and four-bearing crankshafts I have not stated that they are weak. I have stated in the paper however that the crankpins of three-bearing crankshafts must be about twice as large in diameter as those of seven-bearing crankshafts if a certain deflection shall not be exceeded. I have further pointed out that crankpins of three and four-bearing crankshafts are subject to a twist that can be eliminated only by providing a bearing on each side of the crankpins.

FOREST E. CARDULLO:—I agree with Mr. Burkhardt's mathematical deductions, although I have been unable to verify the figures. There is no question that a seven-bearing crankshaft is stronger for its weight or that it can be made of less weight for a given engine than can a three or four-bearing crankshaft.

However, we are not designing crankshafts but engines and I think it will be found that when the engines are designed the best results are obtained from a crankshaft with a lesser number of bearings.

In this connection, I wish to point out that for very short bearings (with length less than one-half the diameter) the load-carrying capacity of the bearings is proportional to the cube of the length. It will be seen therefore that the extremely short bearing theoretically possible with a seven-bearing crankshaft has no load-bearing capacity and that the longer bearings used with a three or four-bearing crankshaft are preferable.

Mr. Burkhardt made a statement regarding the uselessness of balance weights. When balance weights are used, the forces act vertically, reversing their direction once each revolution. When balance weights are not used, the forces revolve, and press against the side of the bearing in a horizontal direction once each revolution. The first condition is preferable from the standpoint of lubrication since the shaft seeks the center of the bearing twice each revolution, allowing the oil film to be reestablished. When the crankshaft is not counterbalanced, side stresses are introduced into the crankcase by the sidewise pressure when the crankpin is at the 90 and the 270 deg. positions. Also pressure is exerted against the bearing on the line of division where we are obliged to place oil grooves. The counterbalanced crankshaft gives a much better distribution of loads and a much better oil film than does the crankshaft without the counterbalance.

With the three or four-bearing shafts the loads produced tend to counterbalance one another so that the disparity in stiffness that Mr. Burkhardt has pointed out does not mean that a corresponding increase in deflection occurs.

The fact that the three or four-bearing crankshaft permits a much shorter engine with a corresponding reduction of weight and decrease of stresses in the parts other than the shaft more than makes up for the theoretical disadvantages of this form of construction.

So far, I have confined my discussion to the purely conventional type of engine. In the case of the twelve-cylinder engine however it is possible to effect a great improvement by the unconventional expedient of setting adjacent crankpins at intervals of 180 instead of 120 deg. The third pin will then be set at an angle of 120 deg. with the first and the fifth pin at an angle of 240 deg. with the first.

The result of this construction will be that a four-bearing crankshaft can be built in which the pins themselves will very nearly, but not quite, counterbalance each other, this without the necessity of using balance weights. Instead of having two three-cylinder engines of relatively great length correcting each other's lack of balance, we will have three two-cylinder engines of very short length doing the same for each side of the twelve. The stresses produced in the crankshaft and also in the crankcase and bearings will be much less than those produced in the conventional forms of the twelve, and the engine will run much more smoothly.

I will have to admit that this unconventional type is attended with certain disadvantages; a peculiar firing order must be used and it is probably that for the best results, three inlet manifolds will be required, possibly served by three carbureters.

The best engine is not necessarily an aggregation of the best details. The best form of crankshaft may be inconsistent with the best oiling system; the best form of cylinder may be inconsistent with the best valve mechanism. The whole design must be a compromise, and the value of any particular element must be considered in relation to the whole design. I feel therefore that although Mr. Burkhardt has pointed out the best design when the crankshaft is considered without relation to the other parts, it is not the best crankshaft for the automobile engine as we know it.

O. M. BURKHARDT:—Mr. Cardullo is in favor of three- and four-bearing shafts because they permit a much shorter design.

In order to judge the case correctly let us assume that a small six-cylinder engine, say 3 by 5 in., be equipped with a three-bearing crankshaft. The distance between the centers of the cylinders would have to be about 4 in. if the engine was designed along conventional lines. In case of a seven-bearing crankshaft we have to place within this distance the length of a crankpin and a journal bearing plus twice the thickness of a crank-cheek.

Crankshaft Bearing Lengths

The length of the crankpin and the journal bearings can be assumed as 1 7/16 in. This length would be only little less than the diameter of the crankpin and the journal. The carrying capacity of the bearings will be directly proportional therefore to the length rather than to the cube of the length. Assuming the thickness of the crank-cheeks as, say 9/16 in., we obtain a distance from center to center of crankpins of 4 in. From this we see that the distance between the centers of two cylinders is equal to the distance between the centers of two crankpins. From this point of view we can expect only that engines of the same bore will be of the same

length, no matter whether a three, four or seven-bearing crankshaft is used.

However, we must further consider that the three-bearing crankshaft cannot last unless it is provided with very long bearings. The longer bearings, as I have pointed out, are necessary to compensate for unequal pressure distribution due to greater deflections. Let us now assume that each journal bearing of the three-bearing crankshaft is ¾ in. longer than each journal bearing of a seven-bearing crankshaft. Further that the crank-cheeks adjacent to the journal bearings must be very thick in the case of the three-bearing crankshaft because of the larger bending moments. The greater thickness of these cheeks plus the extra journal bearing length necessitate that the overall length of a three-bearing crankshaft must be about 3 in. more than that of a seven-bearing crankshaft.

Mr. Cardullo points out that three and four-bearing crankshafts involve a decrease in stresses in parts (presumably the crankcase) other than the crankshaft. Considering the crankcase as a beam we find that with a seven-bearing crankshaft the load is very nearly uniformly distributed over the whole length, whereas a crankcase for a three-bearing crankshaft is stressed like a beam loaded in the middle and supported at both ends. It is hardly necessary to point out in which case the greater stresses are encountered.

REQUIREMENTS FOR FLYING OFFICERS

THE Aviation Section of the Signal Corps announces that although a large number of applications for aviation training are being received there is still opportunity for immediate service for additional high-class men. The following information concerning the service has been authorized:

QUALIFICATIONS OF CANDIDATES

Candidates for commissions as flying officers in the Aviation Section must be at least 19 years old, and preferably not over 30, although in exceptional cases older men of pronounced athletic attainments, who have spent most of their lives out of doors, in the saddle, ranching, playing polo, mountain climbing, or in actual flying, may be accepted if they can satisfy the examining board of their physical fitness.

Candidates should be men of the highest character, well educated, and of good physique. They may be light in weight and youthful in appearance, but applicants will not be recommended who are not in every way qualified and fitted to become officers of the United States Army.

It must be remembered that the flying officer is not an "aerial chauffeur" or "exhibition flier." He has been more correctly defined as "a twentieth century cavalry officer mounted on Pegasus." It is obvious that candidates must be mentally alert, physically perfect, and have well disciplined minds and bodies.

STATUS OF CANDIDATES

All candidates are enlisted in the Signal Corps or the Signal Enlisted Reserve Corps. This will actually hold them for the period of training which covers the course at the school of military aeronautics (ground schools) and at the aviation or flying schools up to the time when, having passed the tests for a reserve military aviator or junior military aviator, as required by the Chief Signal Officer, they are commissioned. If they fail they will be discharged from the Signal Corps and revert to their former status. Failure to qualify for a commission will not exempt from the draft law.

During his entire course of training the candidate for a flying commission has the rank of private (first class), but he may, at the option of his commanding officer, receive temporary detail in such other grades as may be required by the organization of the schools of military aeronautics and the aviation schools. These temporary grades, however, do not carry extra pay, warrants, or commissions, and are only for the instruction of those detailed.

The candidate may be discharged at any time during his course of training by reason of failure to pass tests or examinations, by giving evidence to his commanding officer that he is unfitted either mentally, morally or physically for the duties of a flying officer, or for any other reason which shall in the opinion of the examining board, and subject to such approval as is necessary, render his services no longer desired. The actual mental and physical requirements for a flying officer are so great, his ability to do several things at once and do them all and accurately, are so essential that discharge is not necessarily any reflection on the man's character, loyalty, or devotion to duty.

PAY AND ALLOWANCES OF CANDIDATES

From the time when the candidate is assigned to duty at the ground school until he is discharged or has passed all tests and is recommended for his commission, he receives the pay and allowances prescribed for candidates under the provision of Special Regulations 49, War Department, 1917, except that under present instruction from the Secretary of War the allowance for rations is 60 instead of 75 cents daily. The pay however remains at $100 per month. This rate includes his regular pay as private (first class) and is not in addition to it.

OBJECTS OF SCHOOLS

The objects of the schools of military aeronautics are:

1. To teach candidates their military duties and develop soldierly qualities.
2. To eliminate those who are mentally or morally unfitted to become flying officers.
3. To give the necessary preliminary training in the use of the machine gun, wireless telegraphy, the operation and care of aeronautic engines, assembling and care of airplanes, principles of aerial tactics, cooperation with other branches of the service, and the fundamental principles of cross-country and general flying.

ORGANIZATION OF GROUND SCHOOLS

The organization of a school of military aeronautics includes a commandant, who is an army officer selected by the Chief Signal Officer, to be the commanding officer of the post at which the school is located. Assisting him is an adjutant and a supply officer and a president of the academic board appointed by the president of the

university or technical school which is under contract with the War Department to give the tuition called for in the prescribed curriculum for United States schools of military aeronautics.

For purposes of administrative drill and discipline the candidates at the schools of military aeronautics are organized as a regiment of two wings, divided into three and five squadrons respectively. Each squadron consists of the members of one class divided into three flights. Acting, regimental wing, squadron and flight officers, and non-commissioned officers are temporarily appointed from the candidates. Candidates are quartered in barracks and eat at a regular mess at which they pay board, which varies in different places according to local conditions, but generally amounts to about $1 per day. They must meet this out of their pay of $100 per month and 60 cents per diem ration allowance.

The system of discipline follows that of the Military Academy at West Point so far as practicable. Calisthenics and infantry drill are required daily in addition to the course of technical study. Classes are sent to the schools of military aeronautics each Saturday and graduate after eight or nine weeks.

COURSE OF STUDY

The course of study ordinarily lasts eight weeks and is divided into a junior wing of three weeks and senior wing of five weeks. The work of the junior wing consists of intensive training in military discipline and drill, accompanied by a daily lecture on some military topic, daily instruction in the use of the machine gun, and daily instruction in wireless telegraphy.

The work of the senior wing includes theoretical and practical instruction in military aeronautics.

EXAMINATIONS

No candidates will be sent to a flying school who has not passed all final examinations in the ground school. Candidates who fail, but have an excellent record for conduct and diligence, may, at the option of the commandant, be permitted to repeat examinations. Those who fail to pass or whose record for conduct and diligence is not creditable will be recommended for discharge.

The examinations cover the operation and care of aeronautical engines; theory of flight; nomenclature; rigging; care and repair of airplanes; principles of cross-country and general flying and aids thereto; reconnaissance; ability to use the artillery picture target and miniature range; map reading; principles of and cooperation between aircraft, infantry and artillery; the use and care of machine guns and bombs; signaling; radio; codes; military hygiene; military law and Army paper work, and military organization. Successful candidates are marked as having passed, or passed with honor, and are given certificates of graduation issued by the Chief Signal Officer on the recommendation of the commandant of the school.

TRAINING IN FLYING

Graduates of the schools of military aeronautics are sent to aviation schools for training in flying. These schools are located in various parts of the United States and in territories of our allies.

The course of study at the flying schools depends in large measure on the weather, the supply of "spares," and a man's own ability. It cannot be predetermined as to length. Some men pass their reserve military aviator test and qualify for their commissions at the end of one month, others require longer. Those who have had previous experience in flying usually require less than others, unless their former instruction has confirmed them in bad habits. It occasionally takes longer to correct bad habits than to teach new candidates who have never had any flying experience at all.

At the flying-school instruction in machine guns, signaling, aerial tactics, etc., is continued so far as practicable. As stated above, after a candidate has passed the prescribed tests for a reserve military aviator he is eligible for his commission.

COUNCIL OF NATIONAL DEFENSE IN NEW QUARTERS

The temporary office building now occupied by the Council of National Defense, its advisory commission, and the subordinate committees of both bodies, including the War Industry Board, at Seventeenth and C streets, Washington, contains slightly in excess of 100,000 sq. ft. of space, with heating, toilet and fire-protection facilities customary in office buildings.

The type of construction is wood frame, with wire lath and stucco exterior, and wall-board finish inside. The two main factors governing the plan and erection of the building were economy and speed of construction, as less than 60 days were allowed from the time construction was to have been started until the offices were to be occupied. As a matter of fact, the work was started on Sept. 4 and on Oct. 23 the occupants moved in, a lapse of 49 days, not deducting for Sundays, holidays or bad weather. No night work was done.

The construction required over a million board feet of lumber, and the maximum labor employed was 450 workmen and mechanics of all classes. The cost of the completed structure will be under $225,000, at the rate of less than $2.25 a square foot of space, which is comparable with office rent paid for one year in many cities. So that it is fair to say that if the building is occupied for two years it will save its entire cost in office rent.

The new building will house upward of 600 persons in the personnel of the council and its subordinate bodies. Aside from this, office space has been given to the representatives of the purchasing commissions of the allied governments.

The plans were prepared by Waddy B. Wood, the architect of Washington, to whom much credit is given by the council's committee on emergency construction and contracts, which directed the job. He was confronted with the difficult problem of reconciling a minimum expenditure of money with the requirement that a pleasing exterior and a practical interior arrangement be secured. The contract for the construction was awarded to the George A. Fuller Co., operating under the same form of contract used in the construction of the cantonments. So far as is known, no similar structure has ever been attempted; that is, a building which combines the features of temporary frame construction with the characteristics of permanent office building construction.

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Notes on Aeronautic Progress

By G. Douglas Wardrop* (*Member of the Society*) Metropolitan Section Paper

EVERY military authority today is as one in the belief that aircraft will be the thin edge of the wedge of decisive victory in the Great War. Since the entrance of the United States into the war the Allies are on the eve of securing that aerial supremacy which will enable them in the spring drive, presumably, to gain such a superiority over the Germans that the skies will be cleared of their aircraft.

The aerial conflict will be very much on the same basis as naval warfare. Reconnaissance and fighting machines will engage the similar enemy types, and when one side has succeeded in clearing the skies of these machines, the heavy battle and bombing planes, the dreadnoughts of the air, will be pitted against each other. When this comes it will not be a question of ten or scores; it will be a question of hundreds and thousands of machines.

An aerial campaign must be on a major scale before decisive results can be achieved. Germany, as is well known today, is bending every effort to build up during the winter a fleet of aircraft that will give the Allies, including America, serious difficulty. The Zeppelin factories, every piano factory, in fact every organization that can turn out any part of an airplane, is being utilized for the production of the vast air fleet that Germany hopes to have in the air for the spring offensives. Every known method is being used. The Zeppelins that were recently brought down by the French authorities were found to be fitted with engines of recent principle, indicating that possibly here Germany has the advantage. Furthermore, from various channels we have heard that the linen and fabric stringency in Germany has been overcome, and that today they are stamping out thin metal airplane wings by machinery. These reports have not been verified, but it is reasonable to believe that such development is taking place.

Germany represents a very real opponent to the Allies even with America thrown in the balance. The situation must not be taken too easily, notwithstanding the extraordinary material resources of this country and the fact that the automobile and allied industries have undertaken to help the aeronautic industry in this great campaign to win the war in the air. Every engineer who helps in any way to throw that balance to the side of the Allies will be doing excellent work for the upbuilding of the air service; and incidentally put it on such a substantial basis that it will be one of our most important industries after the war.

At present a committee of eminent men in London, not directly concerned with the war, is preparing routes for aerial mail and rapid transportation after the war. Europe has already been thoroughly mapped out, and South Africa, Australia and New Zealand are receiving attention.

The million and a half people who are engaged today in the manufacturing and production of aircraft will therefore not find themselves out of employment at the end of the war. They will have a definite purpose, that of producing vehicles for the latest and fastest transportation system. Definite plans are even now being laid for the trans-Atlantic flight and for delivering some of our large airplanes by air route.

These are not theoretical generalizations any longer, they are definite and very practical ideas. Only recently an Italian aviator made a non-stop flight of 960 miles; a demonstration in this country, when seven passengers made a journey from Newport News to New York, shows the possibilities of the large machines. These flights merely indicate what is coming. As soon as the question of long-distance traveling is taken seriously a flight from New York to Chicago will be a matter of every-day occurrence. We are but beginning to conceive what a change there will be in our entire commercial traveling.

The changes produced by the airplane will be far greater than those produced by the railroads and the steamboat. The aspect of our cities will be changed. We are not concerned today as to how our cities look from the air, but in the near future as much attention will be paid to the esthetic appearance of our cities from the air as from the streets.

A great change will also take place in legal matters. It is well established to-day that a landlord owns as far down as he cares to go. In the near future, if a man has a large ranch of thousands of acres, he will be perfectly justified in claiming that any man who passes over his territory at a lesser altitude than something yet to be fixed is trespassing.

Man has endeavored to conquer the air for centuries. The Wright biplane, which made a flight lasting fifty-nine seconds in 1904, was the first practical airplane. This flight was hailed as a record throughout the world. At the present time the duration record is somewhat more than twenty-four hours. In 1908 the United States Army had an air fleet of one biplane, but it was the only military organization in the world that was so equipped. Consequently in 1908 our army was supreme in the air. The first French machine that actually participated in modern warfare proved so successful that the European governments recognized the value of aerial cooperation and immediately organized plans for the upbuilding of their air fleets.

Development in Large Airplanes

The Handley-Page represents almost the latest word in the development of the large type of aircraft. It is a twin-engined machine and holds a number of interesting records. A short time ago it carried twenty-two passengers on a journey lasting a little over four hours. It has the altitude record of 7100 ft. for twin-engined machines. A Handley-Page made a journey from the London aerodrome at Hampden to the outskirts of Paris and returned without alighting in a little less than seven hours; this represents about one-half the time of the journey from London to Paris for the fastest railroad and steamboat traveling. It also made a non-stop flight from London to Rome. Handley-Page biplanes were also recently engaged in the bombardment of Constantinople.

The smaller types of Handley-Page biplanes have a useful load of a ton and a half. Other types now under construction will have useful loads of two and a half and

*Editor *Aerial Age*.

three and a half tons. That will mean that the entire plane, together with the load, will weigh from four to five tons.

Handley-Page biplanes are generally equipped with Rolls-Royce engines, although in some cases the Sunbeam engine is used. The propellers are 14-ft. diameter. All the testing for the Handley-Page Company is done by an American aviator.

A great deal is heard at present concerning Liberty Trucks, Liberty Engines and Liberty Bonds, but the important phase of Liberty will come through the air just as soon as the flag flies over Germany.

British Aircraft Inspection Methods

By CAPT. A. BOOR* (*Non-Member*)

METROPOLITAN SECTION PAPER

THIS is my first visit to this country and I certainly consider myself fortunate in being detailed for duty on behalf of the British Government which necessitates my being in a country with such vast resources and opportunities as America.

I should also tell you that anything I say is an expression of my own personal opinions and does not necessarily represent the views of my department.

I have not been connected with aviation very long, although I have been connected with engineering all my life. My experience has been confined to the inspection of aircraft engines. The development both of the engines and the department that inspected them has I think been somewhat remarkable.

I first came in contact with aviation in the beginning of September, 1914, a few weeks after England commenced hostilities. Capt. Bagnall Wild, as he was then, offered me a position in the Aircraft Inspection Department of the War Office. Capt. Bagnall Wild at that time was known as the inspector of engines, and when I joined his staff I found that I was No. 8 on the engine section.

Growth of Personnel

The whole A.I.D. at that time mustered about thirty. I do not know what it musters to-day, but it is probably much nearer 3330, while Capt. Bagnall Wild is now I believe a brigadier general and is known as the Director of Inspection, which means that he is responsible for the inspection of all aircraft.

I remember very distinctly making my application in person for the position which he offered me, and going to a small office in a private house near the Royal Aircraft Factory.

I was just a little disappointed to find such a small outfit, but I discussed the matter and carefully weighed up the possibility of the future development of aviation and on mature reflection thought I could see a big future for aircraft.

I remember very well putting in a week or so at the Royal Aircraft Factory and then being detailed for duty at the works of an automobile manufacturing company in Coventry. This company, which was the first to introduce the sleeve-valve engine in England, had undertaken some of the first Government contracts for Government-designed engines.

I hope it will not be giving away military secrets when I tell you that this first Government contract was for fifty air-cooled engines.

This was an engine of the V-type, which was designed by the Royal Aircraft Factory. It had eight cast-iron cylinders set at an angle of 90 deg. The pistons were also cast iron. It developed just over 100 hp. at 1800 r.p.m. The propeller-shaft was geared down to two to one. While the output of these engines did not run into four figures it was extremely large as production went in those days.

Contracts increased and the increase in contracts naturally necessitated an increase in the number of inspectors that were required. When I next paid a visit to my chief at the Royal Aircraft Factory I found that he and his staff had outgrown his one little office in the private house and were then located in a suite of buildings intended eventually to accommodate some officers of the Royal Flying Corps. Capt. Bagnall Wild I found was occupying the "butler's pantry."

Every one who was connected with the department was keen and enthusiastic and the presence of two sinks for washing dishes in the chief's office did not in any way prevent his putting in seven days a week.

The Royal Aircraft Factory, which was practically a big experimental department, expanded in such a way that house accommodations were exceedingly difficult to get, and special arrangements had to be made to take care of the employees.

My own duties increased and instead of being inspector for Government contracts with the one company only, I was soon made inspector for other contracts at the works of five of our most prominent automobile manufacturers in the Midland district of England.

In those days one had to do his bit and cooperate to the fullest extent with everyone else, and I have cause to remember that one of my difficulties was getting the use of a test machine so that I could pull my test pieces for the materials that were being used.

Preference in those days was given to the munitions people who were making guns, and I found that the machine I wanted to use was so busy that I had to turn out at 6 a. m. in order to get the use of the machine. Long hours were the order of the day and I more often than not had to run my staff until 8 or 9 in the evening.

Methods Standardized

It soon became evident that as our work was assuming such large proportions, our methods of inspection as far as possible should be standardized.

Until then the general lines upon which the inspection was to be carried out had been laid down by the chief, who would make a point of actually visiting the contractor and see just how things were going for himself. He would adjust differences and direct inspection to suit as far as possible the necessity of the particular contractor, but he was one of the first to recognize the need for standardization of the methods of inspection.

With this end in view Brig.-Gen. Bagnall Wild, or Captain as he was then, would often pay me a visit, and

*British Aeronautical Inspection Department.

we would sit in the smoking room of one of our hotels and discuss points in connection with the inspection both of materials and of the finished products.

I would put forth my views based on practical experience and what I had actually found necessary, and he would slash them to pieces just as the censor would mutilate an indiscreet letter. I must not forget to mention that I did the same with any of the views that he put forward that did not fit in with my experience, and I have many very pleasant recollections of sitting up and talking until 2 a. m., straightening out our troubles and laying down suggestions regarding the inspection of aircraft engines.

Methods of testing aero-engines were discussed. This subject interests me considerably and I have had some experience of propeller testing, of fan testing, of testing by means of Heenan and Troude water-brakes and a little experience with the electrical outfit.

While there are probably some disadvantages with the electrical method, at present I am strongly in favor of it. I believe an electrical test-bed can be made to do anything that any other form of test-bed can do; in addition it eliminates some undesirable features of the other test-beds.

After many of these discussions the basis of an inspection procedure was established, and details were finally worked out by the authorities at the London headquarters that resulted in a scheme that could be put into operation at almost any contractor's works.

Changes in Engine Construction

As an improvement on the original eight-cylinder air-cooled engine an increase in cylinder-bore of 5 mm. was tried, but did not meet with much success, because piston trouble was encountered. At 1800 r.p.m. it developed 115 hp., but was not built in large numbers.

The twelve-cylinder air-cooled engine, following closely the lines of the eight-cylinder, was next introduced.

The cylinders and pistons were cast iron and the cylinders were set at an angle of 60 deg. Its propeller-shaft was geared down two to one, and the engine developed 160 hp. at 1800 r.p.m. This engine was subsequently fitted with aluminum pistons, which improved the engine somewhat.

This twelve was fitted to a machine originally designed to take the eight-cylinder engine, and I remember distinctly how keenly everybody watched the tests when the first machine was turned out. Naturally a big increase in speed was obtained.

Rotary engines were of course being built though the 80-hp. Gnome with which I came in contact most was soon recognized as being powerful enough for school machines only.

I remember one incident in connection with the manufacture of the obturateur ring for these engines. Much difficulty was at one time being experienced in getting just the right material for the job and I have always remembered a remark that was made by the chief engineer of a company, with whom I was discussing the situation. He stated that if he was sure that rings made of solid gold would stand up to the work, he would certainly make them.

The point in connection with this is that the employment of poor materials for aero-engines often leads to costly failures.

The power obtained of aero-engines has been increased all along, and the weight per brake horsepower has been decreased. Reduction of weight has been accomplished by design and by the use of materials of higher tensile value than those used formerly.

Much work has been done in this direction but there is one point in my opinion has not received anything like the attention it should have. At an altitude of 10,000 ft. an engine only gives about 66 per cent of the power at sea level. The importance of the point will, I think, be realized particularily when one stops to consider that the aviator's work is done at altitude.

Over a year ago I had an interest in a carbureter that had fitted to it a barometric control for regulating the richness of the mixture but in my opinion this is not enough as other conditions must be taken care of besides carburetion. The method of testing in a vacuum chamber as developed at the Bureau of Standards should be of great value.

It is exceedingly difficult to hazard a guess as to what will ultimately be the standard design for an aero-engine, but I am inclined to think that the all-aluminum engine will make a good showing. I refer not only to water-cooled engines but also to air-cooled engines, for I believe that aluminum can be used satisfactorily for both types.

Another point that designers should attempt to achieve is that of obtaining the required power at altitudes. This might possibly be done in two ways: One by building an engine that would be efficient at a given altitude, and that would be fitted with a control to prevent it from being run at full power on ground level; the other by building an engine that could be efficient at grade level and using a system of supercharging to maintain the efficiency at altitude. The latter appears to me to be the preferable scheme.

The development of aviation in England during this war has been and is very rapid and I have to confess that as I left England last April I feel I am not up to date, at least so far as English practice is concerned.

Crossing the Atlantic

The question of crossing the Atlantic by airplane appears to be absorbing considerable attention, and while I would like to see an English machine make the first crossing, I am sufficiently broadminded to remember that America gave us our first real flying; I can see nothing more fitting than an American machine being the first to make successfully the Atlantic aerial crossing.

Finally, regarding the development, manufacture and inspection of aircraft, I can do no better than to draw attention to the signs that one so often sees in this country. If manufacturers and employees both live up to the slogan of "Safety First" I see no reason why America should not build aircraft that will compete satisfactorily with any that are being turned out.

Steam Engines in the Automotive Field

By E. T. Adams* (*Non-Member*)

IN THE general power field this is the era of steam. In the field of automotive power, even more absolutely, this is the era of gasoline.

The supremacy of steam for general power purposes has been attained only after years of competitive development. The gasoline engine has developed without serious competition and in a very short time. We therefore lack the assurance that its present preeminence in all departments of the automotive field may not be based on causes other than superior fitness for the service, such, for example, as a condition of the oil industry, now outworn, or upon the initial unreadiness of the other types of engines.

At the present time the question as to the relative fitness of the gasoline as compared with the steam engine for automotive service is receiving most serious attention. New developments and new inventions in steam engines have revolutionized the status of steam at the very time when the oil industry has reached a position absolutely the reverse of that which led to, and fostered the growth of, the gasoline engine. Two interrelated economic developments are especially noteworthy. First is the tremendous increase in the demand for automotive power. The use of the automobile has become universal, the use of the truck is at the beginning of an era of expansion which may prove equally great, and the farm tractor marks the beginning of a demand greater than all the others. The farm is the greatest single user of power; few people realize how huge a portion of the earth's surface must annually be cut into slices, turned upside down and pulverized to form a seed bed, and the expenditure of power which this involves. The excellence of the gasoline engine has led to its adoption for this and for other service for which it is economically unfitted, and we are fast working toward a condition where gasoline alone is not produced in sufficient quantity to meet the demand.

Second is the fuel situation. When the automobile industry was young the oil industry was dependent on the use of oil for light, and gasoline was a by-product—cheap, abundant and of excellent quality. Today the oil industry is based on oil for power, and gasoline is its foremost product. The supply, even with lowered quality and new processes of manufacture, is not equal to the demand, and the price is too high for many commercial uses. There will be some gain due to the perfection of vaporizing types of carbureters which will permit further lowering of the quality of gasoline, and some gain due to increased attention to economy, but the growth of the use of power in this field will be greatly hampered unless there is an increase in the quantity of fuel available far greater than can be expected from this source alone. This means the use of oils other than gasoline, and of methods other than carburetion and burning in an internal combustion engine.

The steam-driven engine is the type which most readily meets this condition, and its use will receive a further impetus because the demand for gasoline is a seasonal demand and a steam unit using unpurified kerosene or similar light distillates will use these by-products of gasoline manufacture during the season in which they are produced. These by-products are produced in great quantities, are relatively cheap, and furnish an ideal fuel for the small-power steam boiler.

*Humphrey Gas Pump Co., Syracuse, N. Y.

ADVANTAGES OF STEAM UNIT

The steam unit has many advantages for automotive service. Its high torque at low speed, its overload capacity, its smooth, flexible speed and power control have remained the standards of excellence, reached for but never attained by any gasoline engine. The connection from engine to axle is simple and direct, without clutch, reverse or change gears. Steam is available at full boiler pressure and for practically full stroke to give torque to lift a loaded rear axle slowly and gently from a rut. Ahead and reverse follow the movement of a single lever, and acceleration and hill-climbing capacity hitherto unknown are at the operator's command.

High steam pressures and temperatures have been the rule, but a light, compact engine construction and high economy are attainable with steam pressures between 400 and 500 lb. gage, and thereby we avoid the tendency to carbonize the lubricating oil which is found at higher temperatures. There has been much interesting speculation on the economies due to the use of higher steam pressures and the best division of a given total heat between superheat and the temperature due to evaporation. But in the small units here considered, practical considerations, such as have been outlined, will doubtless govern design.

The chief force which is bringing about the increased use of the steam engine is its superior fitness for automotive service, especially in the commercial field. First, in truck service the upkeep of the gasoline truck, even with expert service, is now beyond reason and is a serious handicap to the business. Overloading and incompetent handling are blamed for this condition, but, practically, overloading is not preventable, and starting from a bad position is an unavoidable hazard. Racing the engine, coupled with the sudden application of the clutch, is the only answer to these conditions which the gasoline engine affords. The result is destructive to both power plant and transmission. The steam engine meets this situation by using steam for practically the full stroke of the piston and at any pressure which the tractive power of the wheel will permit. The available mean effective pressure on the steam piston under these conditions is fully five times the maximum available with a gasoline engine, and the engine speed for the same torque may be correspondingly low. With the steam unit the load is picked up gently, exactly as a locomotive starts a train. This tends toward low cost of upkeep.

Simplicity of Transmission

Another point in favor of the steam unit is the extreme simplicity of the transmission—one pair of bevel or spur gears or direct drive on the worm shaft is all that is required for light and moderate power work, with one additional reduction for heavy work and tractor service. There is no clutch, no reverse gear, only a simple direct drive from engine to axle. This again tends toward low upkeep and long life.

For presentation at the annual meeting, December, 1916, of The American Society of Mechanical Engineers.

In early construction the engine naturally followed locomotive or marine lines. Modern steam engines are preferably of the multiple-cylinder type, designed for quantity production, using the tool equipment and shop methods of the modern gasoline-engine manufacturer. They are carefully balanced, are light and simple and capable of as high speed as may be desired. The uniflow type is largely used because of its simplicity and its high economy when operated non-condensing. Because of the high steam pressure, the most economical mean effective pressure is about the same as full-load mean effective pressure of the gasoline engine, and for the same power the cylinder sizes are about the same in the two cases. With this construction piston and valve require but little lubrication, the amount of lubricating oil necessary being far less than that used by older types of steam or by modern types of gasoline engines. The pistons and rods follow automobile practice. Alloy steel and aluminum are freely used and ball-bearing construction is employed where possible. Crankshafts and pins are oiled by a forced lubrication system, bearing areas are ample, and the labor cost for adjustment and repair is naturally extremely low.

Types of Boiler Design

Boiler design exhibits greater variety than any other portion of the steam unit. The cylindrical fire-tube type, both with and without a water leg, have their advocates. The ordinary flash type is in use, but not so much in favor, because, among other things, of its especial tendency to carbonize any lubricating oil introduced with the fuel. Tube boilers with natural or forced circulation are popular and effective. A forced-circulation, contraflow-tube type seems especially commendable in that it may be forced to almost any degree and is therefore responsive, light, compact and economical. The stack temperatures are readily brought down to 50 deg. above feed temperatures; the superheat is under good control and danger of burning or injury to the tubes is negligible. One advantage of the tube type is its absolute safety from destructive explosions.

All these features exhibit a very great advance over older constructions. They are popular because of their economy and safety, and because all these improvements tend toward longer life and lower cost of upkeep.

The furnace is the most important feature of the modern unit. All precedent is swept aside. With a light power oil as the established fuel there is no excuse for following old practice and merely firing oil into a combustion space originally designed for coal, and in later designs this is not done. First are established proper conditions for burning the oil; second are established proper conditions for utilizing the heat thus generated, and these are then combined. In one installation this leads to a design with the furnace practically at the top of the boiler, with forced feed of oil and air; this has proved a most acceptable and desirable location.

Various methods of controlling the oil are in general service. In the oldest type the oil under pressure is converted into a highly superheated vapor, which discharges past an adjustable needle valve drawing with it an air supply, fed and controlled as in a Bunsen burner. After proper mixing the mixture is burned as it issues from fine perforations in the grate. A pilot light which keeps the oil supply superheated is a necessary part of the equipment. In spite of its high economy and its honorable record in service, this system is steadily being displaced in the more modern designs. Objection is made that under certain conditions the pilot light and the heated oil under pressure are highly dangerous, and the clogging of the control valve by carbon and tars formed by the cracking of the oil is objectionable and expensive.

Control Mechanisms

The mechanical atomizer of the type used in larger furnaces with heavier oils does not appear in use, but would seem to be well suited to the service. New systems of this general class are being tried out very extensively. These systems are important because they consider not only the proper burning of the oil, but also the commercially more important item of control. Considered as a unit, the vital control of the engine must be at the furnace. There must be control in proportion to load, in proportion to steam pressure and to maximum steam temperature, and also control directly responsive to the demands of the public. In a passenger car with a cold boiler enough steam must be generated to enable the car to be driven away in one minute. The mechanism of control, to be commercially successful, must be no more burdensome than the movement of a lever or the throwing of a switch. In a truck or tractor the demands are somewhat more moderate; but in general the steam unit must be practically on a par in the matter of starting with the gasoline unit, and the fact that in this respect also steam is now on a par with gasoline is one reason for the present impetus toward steam.

Where both air and oil are metered in under forced draft and in a boiler so flexible as those here described, it appears that a simple and entirely satisfactory method of heat graduation is to "cut in and cut out"; that is, to stop the supply of both oil and air entirely where it is desired to limit pressure or temperature, and to cut in again at full power when the pressure or temperature falls, this action of course being entirely automatic. With the safety which a tube boiler provides, a satisfactory system of water supply is a feed-pump operated by any means whose speed or time of operation is directly proportional to the load. This involves attention to the water level and occasional adjustment by the operator, but as there is no serious penalty for his failure, this seems an entirely satisfactory method—perhaps more satisfactory than a type more strictly automatic.

Next to the fuel situation and the desire for reduced cost of upkeep, this new system of control is the most important development affecting the renaissance of the steam engine in the automotive field.

The exhaust is condensed to atmospheric pressure in an ordinary type of automobile radiator. The type with wide surfaces and thin water spaces has proved most effective. In a passenger car complete condensation is secured in a small radiator often without the use of a fan. The efficiency of the radiator is reduced by excessive oil in the feed, but otherwise there are no disagreeable effects. Under these conditions fresh-water supply is needed only at rare intervals, which again is a feature that has served greatly to increase the demand for the steam engine.

Comparison of Economies

It is characteristic of the internal-combustion engine that it gives its highest economy at its maximum load, with rapid reduction in economy as the load is decreased. The reverse is true of the steam unit. It results from this that under usual operating conditions the steam unit is operating at its maximum efficiency, whereas the gasoline unit is operating at only fair efficiency. These efficiencies tend to meet, and in the two cases in actual service the quantity of fuel per brake horsepower per hour

should not be different, at least to any material extent.

The difference in cost between gasoline and power oil, when coupled with a reduced cost of lubricating oil, represents an appreciable reduction in fuel cost in favor of the steam unit and one of importance to the truck and tractor operator. In the case of the automobile, where a small horsepower represents great mileage, this item is of lesser importance; but it lends romance to engineering to note that the joy of driving the smooth, flexible steam engine is likely to cause its extensive adoption, first in the field which commercially needs it least.

In our interest in newer conditions and later developments we should not overlook the splendid record of the builders who have long been prominent in this field. It is this pioneer work which has demonstrated the advantages and emphasized the deficiencies of the steam unit and has formed the basis on which the engineer of today is building.

From the earlier experience with steam power we have learned the necessity of treating the various elements of a steam-power plant as parts of a single unit. From the internal combustion engine we have learned the necessity for design on a production basis. From the oil industry we have learned what fuels are most readily available, considering both method of manufacture and distribution. And from the public we have clear-cut demands based on extended experience with both gasoline and steam in all classes of service. The designer of the steam unit, therefore, has before him unusually complete data relative to all phases of the problem.

On the part of the manufacturer and of the public there is evidence of tremendous interest. Numbers of new trucks, tractors and passenger cars are in service, or in process of manufacture or design. This effort and this demand will have a profound influence on the automotive industry. Whether it shall result in the supremacy of steam over gasoline is of minor import. The important fact is that it will surely result in a tremendous broadening of the usefulness and influence of automotive powers.

Petroleum and Its Products

By Van H. Manning — Director, Bureau of Mines

THE average person fails to realize the importance of petroleum and its products in the ordinary routine of the world's work, yet every man, woman, and child in America is dependent in some measure upon petroleum and natural gas. There is scarcely a phase of our national life in which we do not find petroleum products used—they drive our battleships, deliver our merchandise, pull our trains, heal our wounds, color our garments, smelt our ores, carry our mails, cook our meals, and increase our knowledge of the outdoor world.

Every industry makes some use of petroleum or its products, and to list all of the uses would not be feasible here. It is sufficient to say that petroleum is essential to the commercial development of the country, and that if our supply were cut off today, our industrial progress would be brought almost to a standstill. It has been said that when petroleum is gone, electricity will take its place, but, although electricity will furnish power for our industries and lights for our homes, it will not lubricate even the machinery needed for its own generation.

The Navy is dependent on the petroleum industry not only for lubricating oils but to an increasing extent for fuel. Battleships that use oil as a fuel can carry larger armament, and have a greater range of action than those that use coal. Petroleum is thus vital to our national defense and perhaps to our national existence.

Limitations of Supply of Petroleum

What shall we do when our supplies become depleted? Although this country has large known reserves of petroleum, these supplies are limited. At our present rate of consumption our estimated supplies are sufficient to meet our present needs for a comparatively short period, conservatively estimated to be from twenty-five to thirty years, taking no account of the increasing demand for petroleum and its products. This estimate not only includes the oil fields already known and developed, but makes liberal allowances for undiscovered fields in prospective oil territories. It should not be thought that our petroleum supply at the end of that period will be cut off abruptly, for the wells will continue to produce through a declining output for many years. On the other hand, the shortage of petroleum is beginning to be felt now. A good measure of the accuracy of these estimates, which were made more than a year ago by the Department of the Interior, is the result of the search for oil the past year. Owing to the demand for crude oil, more territory was prospected and more wells were drilled in search of petroleum in the Mid-Continent field than in any previous year. During the year 1916 there were approximately 15,000 wells drilled in that field, as compared with 6000 wells drilled in 1915, yet the production today will not equal that of two years ago, nor have any large new oil fields been developed.

What effort have we made to conserve this supply and to utilize it to its greatest advantage? We have made little effort until very recently to do these things. We have been wasteful, careless, and recklessly ignorant. We have abandoned oil fields while a large part of the oil was still in the ground. We have allowed tremendous quantities of gas to waste in the air. We have let water into the oil sands, ruining areas that should have produced hundreds of thousands of barrels of oil. We lacked the knowledge to properly produce one needed product without overproducing products for which we have little need. We have used the most valuable parts of the oil for purposes to which the cheapest should have been devoted. For many years the gasoline fractions were practically a waste product during our quest for kerosene; with the development of the internal-combustion engine the kerosene is now almost a waste product in our strenuous efforts to increase the yield of lighter distillates.

This country is producing about two-thirds of the world's output of crude petroleum and has produced approximately 2,750,000,000 barrels since the drilling of the first oil well by Colonel Drake in 1859. Our future supply from both proved and prospective oil fields, based on

*From the recently issued 1916 Yearbook, Bureau of Mines.

geological possibilities, is estimated to be approximately 7,402,000,000 barrels, which will last us only about twenty-five years at our present rate of consumption. We are exporting 20 per cent of our production, using approximately 25 per cent as fuel under boilers, and of the remainder probably one-fourth is wastefully utilized. Thus 70 per cent in all is being used in a manner that must be considered anything but conservative for so valuable and so scarce a product.

As an example of wasteful utilization, a large proportion of our artificial gas is made from petroleum, notwithstanding the fact that coal has been and is used for this purpose, and would be used altogether except for the reason that the gas manufacturer is able to buy petroleum cheaper. At the present rate of production it is estimated that our coal supply is adequate for many centuries. Clearly we should not use our petroleum for fuel under boilers or for gas manufacture, or in any way to compete with coal, when the oil supply is so limited.

Growing Consumption of Gasoline

Gasoline is indispensable to our present industrial progress. At the present time there is a greater demand for gasoline than for kerosene, fuel oil, or any of the other petroleum products. There are now over 3,500,000 automobiles in use in the United States. The manufacturers are turning out approximately 1,500,000 new machines this year, and expect to increase the number each succeeding year. The average consumption for each automobile is more than ten barrels of gasoline a year, and it is estimated that this country will need more than 2,000,000 gallons of gasoline for the year 1917. Where is this gasoline coming from?

Methods of Producing Gasoline

The situation can be partly met by converting some of the less valuable products of crude oil into gasoline. The Bureau of Mines early realized the importance of this conversion and during the year 1915 one of its chemical engineers, Dr. Walter F. Rittman, discovered a "cracking" process by which gasoline, as well as benzene, toluene, and other desirable products can be made from kerosene and other crude oil distillates. Other cracking processes have been invented, but they have been privately owned and not readily available to the small refiner. The Bureau of Mines hopes to make the Rittman process available to every user.

It is estimated that 2,000,000 barrels of gasoline was made by cracking processes during 1915, some refineries obtaining as high as 35 per cent of gasoline from some oils. During the year 1916 it is estimated that 5,000,000 barrels of gasoline were manufactured by cracking lower grade products. This output is all the more striking when it is considered that these 5,000,000 barrels will be made from oils that in the past did not enter into the making of gasoline.

The Bureau of Mines has for a number of years realized the importance of taking steps to introduce methods by which wells may be driled more economically and with less waste of oil and gas to increase the amount of oil that may be extracted from an ordinary formation, and above all to conduct investigations that will bring about a greater efficiency in the utilization of this precious commodity. To carry on work along these lines the petroleum division of the Bureau of Mines was organized, and up to July 1, 1916, had spent about $100,000 in this work. The manner in which this money has been expended and the resulting benefits to the public form an interesting study for anyone interested in the petroleum industry.

Organization and Work of the Petroleum Division

The petroleum division of the Bureau of Mines is divided into four sections, as follows: (1) Cooperative and administrative work, (2) production technology, (3) engineering technology, and (4) chemical technology. The cooperative and administrative section supervises the work of the Division, conducts its correspondence, and carries on work in cooperation with other governmental agencies.

The section of production technology conducts investigations with a view to increasing the proportion of petroleum and gas recovered from the earth and carries on studies regarding the exclusion of water from the oil sands and the prevention of other underground wastes. The section also investigates current oil-field practices throughout the country with a view to the more general adoption of the most efficient and economical methods of producing the oil and caring for it. Men with long practical experience in drilling and caring for oil properties are held ready to advise oil operators who desire expert opinion as to the best methods to be used in solving any difficult problem.

The section of engineering technology conducts investigations as to the design, construction, and operation of pipe lines, storage tanks, earthen reservoirs, and similar problems connected with the engineering side of the petroleum industry. A special study has been made of steel storage tanks and of the loss of oil in storage, including both losses by evaporation and losses by fire. Also, the section has studied in detail the manufacture of gasoline from natural gas.

The section of chemical technology studies methods and practices for refining and treating petroleum and its products, and is the section in which the Rittman process was developed. This section carries on research work in connection with the refining and testing of petroleum, and is working on the study of the processes for deriving oil from shales with a view to determining the future economic possibility of the oil-shale industry. This is a large and important field of work, and it is expected in the future to materially assist in introducing new practices in refining that will, to a certain extent, aid in the efficient utilization of our petroleum.

Cooperative and Administrative Work

The purposes of the petroleum division have been three: First to place before the public the significance of the tremendous waste of oil and gas and, if possible, to cooperate with State legislative bodies and Federal bureaus to reduce and to prevent excessive wastes of oil and gas; second, to carry on investigations whereby a greater percentage of the oil may be extracted from the sands; and, third, to place in commercial use various methods that will insure a greater utilization of this country's petroleum resources.

Millions of cubic feet of natural gas and millions of gallons of oil have been wasted for days and days in a careless and reckless exploitation of our oil and gas fields. The productive districts in this country have now been fairly well defined, and in spite of the constantly increasing demand for these unrivaled fuels the production must within a comparatively short time begin to decline. Hence, it is of the highest importance to the nation that the remaining supplies of these fuels be protected and the tremendous waste in their production be prevented, and it is this end that the administrative and cooperative section holds in view.

Many of the States have already recognized the need of preventing waste and have enacted laws for that pur-

pose. Unfortunately however such legislation has in many instances proved ineffective, because it did not have the confidence of oil operators and because it was difficult to enforce. The Bureau of Mines is in a position to bring together producers and marketers of petroleum and natural gas so that their cooperation may be obtained and measures to lessen wastes may be made effective.

Examples of Aid to States

A few months ago when the people of Oklahoma realized the tremendous waste of natural gas and oil in the prolific Cushing field, it became necessary for the State legislature to prepare and enact into law a bill making it compulsory for the oil operators to conserve these resources. The assistance of the Bureau of Mines was requested and was promptly given. The law is now in force and is spoken of as one of the best conservation laws in the United States.

The bureau stands ready at any time to furnish any possible similar assistance to any organization or State for the purpose of conserving petroleum and natural gas.

Another interesting example of assistance given by the Bureau of Mines also concerns the State of Oklahoma. The commercial club of a small but thriving city, realizing that much of the surrounding district's prosperity depended upon the conservation of its oil and gas, requested that the bureau recommend to them a practical man whom they could employ for the purpose of enforcing the regulations of that State in connection with the conservation of its petroleum resources. The committee asked that this man be allowed to work under the supervision of the Bureau of Mines. A man was finally appointed, his salary and expenses being paid from moneys subscribed by the commercial club and by representatives of the various industries in the community, and under the bureau's direction many millions of cubic feet of natural gas have been conserved and saved for the future, while in the nearby districts, where no such close scrutiny was given the oil and gas operations, all the gas has either been blown into the air in an effort to find oil or has been dissipated in the porous formations underground. The Bureau of Mines desires to see more of this sort of work done, as it not only results in the conservation of oil and gas, but insures the future prosperity of many of the industries upon which such cities are dependent.

Production Technology

The section of production technology of the bureau's petroleum division studies the drilling of oil and gas wells and the production of oil and gas.

The drilling of oil and gas wells is not a simple matter, and only a small percentage of the people of this country realize that it costs thousands of dollars to drill a hole over half a mile deep for the purpose of discovering oil and gas. Many oil wells are nearly a mile in depth. Oil and gas exist ordinarily in porous formations at varying depths below the surface, and if it were possible to drill wells for oil and gas in the same way that wells are drilled for water, not so many problems would be encountered. But the holes must be drilled through caving formations and through formations containing great quantities of water or gas under high pressure. Heavy pipe ranging in diameter from 4½ to 20 in. must be used to prevent the caving of the formations and to exclude water from the drill hole.

There are two general methods in use in the United States for drilling oil or gas wells—the standard or cable-tool method, in which a percussion drill is used, and the rotary system, in which, as the name implies, the drilling is done by rotating a string of pipe on the end of which is a bit that cuts through the formations in the same manner that a drill bit cuts through a piece of metal.

With the standard method the first drilling is done with a large tool called a "bit," which is raised by powerful machinery and allowed to drop, grinding up the rock. As soon as the hole reaches a depth at which caving begins, a heavy "string" of casing is screwed together and set on the bottom of the hole, and another bit of a smaller size, which will go inside the casing, is lowered into the well, and drilling is resumed in the smaller-sized hole. When found necessary the bit is removed and a long string of casing, smaller in diameter than the first casing, is set on the new bottom of the hole and operations continued with the smaller bit. This is done until the oil sands are encountered, the strings of casing resembling a great telescope.

Many difficulties are connected with drilling such wells, and the bureau's engineers are continually studying the problems of operators in different fields of the United States. These engineers are sent from field to field to advise with operators when requested to do so. In this way the Bureau of Mines disseminates much information of value to the oil operators.

Need of Technical Control in Well Drilling

As outlined above, the drilling of oil and gas wells is a difficult engineering operation; it requires the expenditure of much money and labor, and demands high engineering skill. However, all drillers and many operators are not familiar with the most efficient methods of drilling through gas-bearing formations and often do not adequately protect oil and gas measures from contamination by water or from underground dissipation. For this reason and because of the great volumes of oil and gas being wasted, the bureau undertook to introduce into Oklahoma new methods of drilling that would result in a conservation of oil and gas. Some specific instances of wells at which large volumes of gas were wasted follow.

Example of Gas Waste

In 1914 one of the first wells drilled in the north Cushing field wasted an average of 14,000,000 cu. ft. of gas each day for sixty-seven days, or a total of 938,000,000 cu. ft. A little later the same well struck another sand and wasted about 40,000,000 cu. ft. of gas each day for seven days, or a total of 280,000,000 cu. ft. From these two sands this well wasted 1,218,000,000 cu. ft. of gas, which, if it had been sold at the average price of gas consumed in the United States at that time, would have brought $182,700, and even if the producer had sold the gas at customary field price he would have obtained from its sale over $25,000, or more than enough to drill a well. This amount of gas wasted is equivalent to about 60,000 tons of coal, or about 250,000 barrels of oil, and is sufficient in volume to furnish over 12,000 families with gas for one year. Had this well been the only one to represent waste, it would not have been so regrettable, but as a matter of fact the gas wasted by this well was only a small proportion of the total amount wasted in the Cushing field.

Effective Methods Demonstrated

The Bureau of Mines sent engineers to this field to reduce the waste by teaching an efficient drilling method. In a few months it was proved beyond doubt that wells drilled through these tremendously productive sands need

not waste so much of the gas. The method demonstrated not only conserved the gas and kept it underground where it could not be wasted, but rendered the field safe for workmen and for visitors, and also greatly reduced the time of drilling wells, for previously when an operator struck a high-pressure gas sand he had to allow the gas to needlessly waste into the air until the pressure had declined enough to allow him to continue drilling.

USE OF MUD-LADEN FLUID IN DRILLING

The method of drilling advocated by the Bureau of Mines is called the "mud-laden fluid" method.* This method may be outlined as follows:

The term "mud-laden fluid" is applied to a mixture of clayey material that will remain suspended in water for a considerable time and is free from sand, limestone cuttings, or similar materials.

The action of mud-laden fluid in a sand or other porous formation can be likened to the action of muddy water going through a filter. In any filter that has been used for some time it will be found that most of the sediment from the water has been deposited on the surface of the filter, but some of it has entered the filter, the proportion diminishing with the distance penetrated. The distance to which mud from the fluid in the well will penetrate a porous formation depends partly on the combined pressure produced by the column of fluid and the pump, and partly on the consistence of the fluid and the porosity of the formation. At first the fluid will enter the formation, but finally the mud will clog the pores and no more water will go through. Ordinarily, if a thick fluid is used on the sands encountered in the well, it will not penetrate to any great distance even under high pressure, but if the fluid is too thin it may not clog the pores readily and will act more like clear water, which may enter a sand indefinitely. Occasionally a very coarse sand, a fissured formation, or a porous limestone is found into which even thick fluid may penetrate for some distance.

When a well has been treated with mud fluid the contents of each formation is confined to its original stratum, so that there can be no movement of oil, water, or gas either from the sands into the well, from the well into the sands, or from one sand into another. Thus waste and intermingling are prevented, corrosive waters cannot reach and attack the casing, and the strata are entirely sealed off from each other as they were before the well was drilled.

Consistence of Fluid to Be Used

The consistence of the fluid should be varied according to the conditions for which it is to be employed. Most frequently mixtures with a specific gravity of 1.05 to 1.15 are used in drilling. When the fluid is not used to drill in, thicker fluid is often employed, which has the advantages of greater weight and of clogging the pores of the sand more readily. Experience soon enables the operator to judge the consistence of fluid required for practical uses.

The operator who is unfamiliar with the use of mud-laden fluid is likely to use it too thin. This has been the cause of much trouble in Oklahoma. Such fluid acts almost like clear water. It will not clog the pores of the sand readily and hence will be forced into them for considerable distances, and in some instances nearby wells have been affected. It is also likely to cause caving and is injurious to the sand, or it may not have sufficient weight to overcome high-pressure gas. The only limit on the thickness of the fluid that may be employed is whether it can be handled by the pumps, for it must be a fluid and not a pasty clay.

*Bureau of Mines, Bulletin 134.

Cost of Oil Wells

In the drilling of oil wells, with the expenditure of vast sums of money, many problems arise. Each well costs thousands of dollars and requires many weeks of labor in drilling. After oil is discovered many more problems are encountered by the producers in extracting the oil from the ground. At some wells as soon as the drill penetrates the oil sand, oil and gas in tremendous volumes are expelled from the hole, and if the producer is lucky enough to have storage tanks, he may make money easily while the well is flowing.

Oil properties are unlike mining properties, where a certain amount of ore is mined each day and that amount can be increased by putting more men to work. Very often an oil well "comes in" at a high rate of production which lasts for a number of months, gradually diminishing in daily output, however, as the underground pressure in the oil sand is released. As a result the well makes a constantly diminishing daily production, and oftentimes after a few months it becomes necessary to place tubing in the well and pump the oil from the sands. Some wells produce for many years, but often one-half of a well's total production is obtained the first year and it requires all the rest of the years of the well's life for the operator to obtain the remaining half of the oil.

It has been estimated that oil operators are obtaining only a part of the total oil stored by nature under their lands. Estimates of the total amount extracted range from 10 to 70 per cent, 90 to 30 per cent being left in the ground. It is estimated that this country in the future will produce over 7,000,000,000 barrels. If the Bureau of Mines is able to cause the adoption of practices whereby this production is increased by 10 per cent, it will cause an increase in the ultimate production of 700,000,000 barrels or a sufficient amount to meet the present demand for about two years. Placing the same price per barrel on this crude as was obtained for the crude oil throughout the United States for 1915, there would be a saving to the country of $450,000,000. Even an increased ultimate production of 1 per cent would yield a total net saving of $45,000,000, a sum far in excess of any amount which will be spent by the Government for investigations of petroleum and natural gass.

Efforts to Increase Oil Production

The engineers of the bureau are making extensive investigations with a view to recommending the most feasible methods of increasing the extraction of oil by the use of compressed air or the use of a vacuum. The principle of one of the most promising of these processes is the forcing of compressed air into the porous oil sand, thus forcing the oil in every direction from the point of entry of the air. The oil is then pumped from the wells near by. In some cases partial vacuum is put on the sand by the use of suction pumps. These pumps draw the oil and gas toward the well to which the pumps are attached.

Water is the oil man's greatest enemy. The filtration of water into the oil sands means either a total loss of the oil or a comparatively short flow. This has been true with hardly an exception for every oil field in the world. In many oil fields divided among a number of operators there are great differences in the methods used to get the oil, and occasionally an operator who has had

very little experience, and does not realize the harm he is doing, does not carefully exclude from the deep oil sands the water in the shallow sands. The water not only ruins his well, but rapidly spreads from well to well, decreasing the amount of oil recovered, "cuts" the oil, and spoils the field.

The Bureau of Mines has already issued a report* on the cementing of oil wells, which means the exclusion of water from the oil by the use of cement. This practice is followed almost universally in the California fields and in some of the Texas fields, and the bureau hopes by conducting extensive work to induce operators in other fields to adopt similar methods. As our petroleum resources are limited, we cannot afford to allow great quantities to be ruined because some operator has been neglectful in the methods he has used in finishing his well. The bureau is to issue a report on the methods used for excluding water from oil sands as practised in all the fields of this country, which will be written with a view to recommending the best practice to be followed under varying conditions in different fields.

Corrosion of Well Casings

The corrosive effect of underground water on casings is another difficulty that oil men must combat. Casing in oil wells is used primarily to exclude water and loose material, and as some underground waters contain acids, casings in such wells are rapidly corroded, and water runs through them into the oil sands. The casings may be protected from the corrosive effect of water by the use of mud-laden fluid, but in case operators desire to use some other method to obviate this difficulty the bureau hopes to be able to suggest alternatives.

ENGINEERING TECHNOLOGY

The section of engineering technology of the petroleum division is studying evaporation losses and fire losses in connection with the storage of oil, with a view to reducing these losses by suggesting improvements in the design and protection of tanks. The magnitude of evaporation losses may be realized by considering that out of 50,000 barrels stored in one tank in Oklahoma between 2000 and 2500 barrels were lost by evaporation in five months. There are probably between 3000 and 4000 large oil storage tanks in Oklahoma today, and although they do not all now contain oil, and it is not reasonable to suppose that such tremendous losses occur from every tank, the evaporation loss is undoubtedly appalling. In addition to this loss, many tanks are lost by fire caused by lightning during certain seasons of the year, and it is a common occurrence in the oil fields during a thunder shower to see a great tank containing thousands of barrels of oil burning rapidly.

When oil is produced it is almost always accompanied by more or less gas, which ordinarily comes from the same sand. The gas usually contains some of the lighter portions of the oil itself. Such gas is known as "wet" gas, and if it is produced with the oil it is called "casing-head" gas. A few years ago one could go through almost any oil field in this country and see great volumes of this gas escaping from the oil tanks. No one could see any way in which it could be utilized, although at some wells it was trapped and used for fuel under boilers. It was soon learned, however, that by compressing this wet gas and cooling the compressed product, gasoline of high gravity was precipitated. A few years ago gasoline was not so expensive as it is now, and inasmuch as the so-called "casing-head" gasoline was more or less dangerous on account of its volatility, not many people cared to handle it. However, after the automobile came into its own, and gasoline became so expensive, the use of casing-head gasoline began to be more and more common.

*Technical Paper 32, Bureau of Mines.

Processes for Making Casing-Head Gasoline

Casing-head gasoline is made by two different processes, the compression process and the absorption process. In the compression process the wet gas is compressed by large machines to a pressure between 200 and 300 lb. to the square inch. The compressed product is then cooled and the "wet" parts of the gas condensed. The high-gravity product is then mixed with low-gravity distillates and kerosene, which cannot be utilized by themselves in automobile engines. However, the addition of the light-gravity gasoline gives the resulting mixture a volatility sufficient to permit ready combustion in automobile motors.

The absorption process of making gasoline may be used for casing-head gas or for gas that does not occur with the oil. This process is based upon the fact that when the wet parts of the gas are forced through certain kinds of oil used for absorption the oil absorbs the light particles of gasoline carried by the gas. These are later recovered from the oil by heating it, the gasoline being driven off and the high-gravity product being condensed. The product of the absorbers is blended with a heavier distillate, as is the product from compressing casing-head gas.

Value of Waste

During the year 1915 approximately 1,500,000 barrels of gasoline were made by these methods. The value of this gasoline is about $5,500,000, showing the magnitude of an industry based upon a product that until a short time ago was allowed to waste into the air. This engineering problem is being thoroughly investigated by engineers connected with the Bureau of Mines.

CHEMICAL TECHNOLOGY STUDIES

One of the most important results obtained by the section of chemical technology was the development of the Rittman process, which allows a greater percentage of gasoline to be obtained from petroleum than was obtained by other processes. This greater percentage is obtained by subjecting the heavier distillates of petroleum to "cracking," which involves the rearrangement of the molecules of oil by subjecting them to high temperatures and pressures. The Bureau of Mines early realized the importance of this process, and as a result of the studies carried on by Dr. Rittman important discoveries were made, which bid fair to greatly increase the present supply of gasoline. The Rittman process has proved to be of unquestionable value, although unfortunately not many refineries have installed the necessary equipment for utilizing it.

One of the large fields in refining is that connected with the so-called unsaturated hydrocarbons. Petroleum practice of the past has always dealt with saturated hydrocarbons, namely, those that are not washed out by sulphuric acid. From the chemist's standpoint the saturated hydrocarbons are inactive, whereas those constituents that are unsaturated are most active chemically, and can be used as a source for building up a great variety of products. The Bureau of Mines desires to extend the scope of such work, and recommends this field of research because of its tremendous possibilities.

Another investigation that the bureau desires to continue is the development of the Rittman process. With the present limited appropriations made for petroleum investigations the bureau has not been able to carry on investigations in the field of possible by-products to be made from the cracking of oils. It seems clearly possible to make such by-products as special lubricating oils, aromatic hydrocarbons, and other hydrocarbons that can be used in making drugs and antiseptics. During the past year the Rittman process for making gasoline has passed beyond the experimental state and may be considered a commercial process. During the experiments carried on by the Standard Oil Co. of New Jersey at the Rittman Process Corporation's plant at Pittsburgh, as much as 100 barrels a day were treated in a 11-in. cracking tube, with a recovery of 40 per cent gasoline having an end point of 165 deg. cent., whereas the end point of what is now termed gasoline is nearer 200 deg. cent.

The independent refiners have been slow to take up the process, and consequently its development has been retarded. The Bureau of Mines has been handicapped in that it has not had a plant at which it could carry out tests on a commercial scale. The licensees, as a rule, are not interested in developing the chemical possibilities of the process so much as in obtaining the products they desire. If the maximum progress is to be made in the development of the Rittman process, it seems necessary for the Bureau of Mines to control a plant at which commercial quantities of oil can be treated, and to which persons interested in the process can send carload lots of oil to be tested before they invest in the construction of a plant. The labor costs of making such a test should be charged against the applicant for the test.

Contemplated Investigations

In the future the bureau hopes to investigate sulphuric acid residues from the refining of petroleum; the possible by-products obtainable from acid sludges and cracked oils; and the internal-combustion engine fuels, which will involve the testing of various grades of such fuels for the purpose of determining relative efficiencies and satisfactory end points and other limits. The bureau also hopes to investigate and prepare specifications for lubricating oils and to standardize as nearly as possible the methods of testing petroleum and all its products. The best method of analyzing crude oil must be studied. Gasoline, which is one of the nation's greatest necessities, is being thoroughly investigated, and thousands of analyses are being made to determine the grades of gasoline being used in different parts of the United States, so as to enable the Bureau of Mines to furnish expert information to State governments and private individuals as to the essential properties of gasoline for various uses.

During the past year the increasing demand for gasoline has been met in four ways: By stimulating production; by the use of a cracking process controlled by the Standard Oil Co.; by increasing the end point from 150 deg. cent., the end point of a year ago, to an end point as high as 200 deg. cent., which has permitted the use of large quantities of distillate that was formerly considered to be naphtha and kerosene stock; and by blending casing-head gasoline with heavy naphtha or light kerosene stock. It is impossible to count upon an increased production of crude to keep pace with future increases in the demand; likewise it is impossible to expect a much further raising of the end point without a decided change in engine designs, for the reason that the present end point includes most of the products that can be heated up to their vaporizing point without cracking, and if the products are heated above their cracking point objectionable decomposition products are formed. The casing-head gasoline industry will probably never furnish more than 10 per cent of the total production of gasoline; therefore, the only possible way of keeping pace with this increased consumption of gasoline is by means of cracking the heavier oils. We are today using efficiently—that is, for gasoline and lubricating purposes—not more than 30 per cent of our oils. The other 70 per cent is used in competition with coal or exported to foreign countries, and is generally sold for less than the cost of production. The gasoline problem before the public today can probably be most efficiently solved by cracking this 70 per cent of petroleum, thereby increasing the yield of gasoline from our present oil production by 100 to 200 per cent.

Extraction of Oil from Oil Shales

The question is being asked daily what this country is going to do when our petroleum resources are exhausted. We have as yet untouched our great reserves of shales that contain oil. These shales are found in many parts of the United States, and tremendous reserves are known in Colorado, Utah and Wyoming. There is only one country in the world where oil shales are being utilized for the production of oil—Scotland, where little petroleum occurs, and where the demand for petroleum is great. Some of our shales are much richer in oil than are the Scotch shales, and are conservatively estimated to contain many times the amount of oil that has been or will have been produced from all the porous formations in this country.

To obtain the oil from oil shale it is necessary to heat the shale in great retorts. The oil is the result of destructive distillation, and is driven off in the form of vapor, and is later condensed by cooling. As stated above, this process has never been used in this country because of lack of necessity, for our oil reserves are great, and it would not be commercially economical to invest money in retorts for distilling from shale oil that would have to compete with the crude oil obtained by other methods. But this condition will not last forever. In fact, it will probably be only a very short time until the oil-shale industry will be one of magnitude.

is another difficulty that oil men must combat. Casing in oil wells is used primarily to exclude water and loose material, and as some underground waters contain acids, casings in such wells are rapidly corroded, and water runs through them into the oil sands. The casings may be protected from the corrosive effect of water by the use of mud-laden fluid, but in case operators desire to use some other method to obviate this difficulty the bureau hopes to be able to suggest alternatives.

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Traffic Regulation at Corner of Fifth Avenue and 42nd Street, New York

Applications of Traffic Census

By D. B. GOODSELL* *(Non-Member)* *Illustrated with* PHOTOGRAPH

A CENSUS is but one of several things to be considered in designing a road, including determination of the kind of surface and the width, and an inventory of all the factors affecting it must be taken into account before a final conclusion is reached. The writer does not believe that highway engineers are determining roadways, or the location where main arteries of travel should be improved, solely by scanning a traffic census. There are too many other controlling conditions and the census is too little known and used, as yet, to be of much service. Nevertheless, it has a place in the design of country roads, and has loomed up recently with a large and important aspect in great cities, as will, I believe, be shown later.

In fixing the width of any roadway surface, the number of lines of traffic to be accommodated should be given consideration. The statement has been made that where a vehicle has to turn from the hard surface of a road oftener than five times a mile it is cheaper and far safer to construct the additional width of road surface which may be required.

The necessary amount of clearance which a vehicle must have to pass safely depends on the speed. The average width of vehicles in New York City has been found to be 6 ft. 9 in., large trucks occupying as much as 8 ft. or 9 ft. At slow speed, say 10 miles per hour, with the average width, the width of a single line of automobile traffic, including clearance, would be about 8 ft., and at fast speeds 9 ft. or more. On Fifth Avenue, New York City's busiest avenue, there are 6 lines of automobile traffic occupying 55 ft., the speed being between 5 and 8 miles per hour. It is obvious that if the roadway had been made, say 3 ft. narrower, another line of travel—or possibly two—would have to be sacrificed. The width of the Fifth Avenue roadway was originally 40 ft., accommodating 4 lines, with too much clearance. It was widened 15 ft., and now takes 6 lines, with a safe clearance. It is obvious that great congestion would have occurred, and much inconvenience to the public, had the street continued with only 4 lines of traffic and its excessive width.

On a suburban or country road accommodating motor traffic, the additional clearance required by an overtaking car should be considered. When moving at, say 25 miles per hour, at least 4 ft. of free way should be given the overtaken car to avoid accident due to unexpected deflection from its course. A width of 20 ft., for this reason, is better than 18 ft., for 2 lines of travel, and 30 ft. is ample for 3 lines.

In the Borough of Manhattan a realization of the necessity for widening the narrow crosstown roadways of the mercantile district, and some of the north and south avenues as well, took shape in 1911, and has resulted since then in the widening of 14 streets and avenues 35,012 ft. in length, and apparently the work has just been begun. On all of these streets, a 10-hour census of the vehicular and pedestrian traffic was taken, and resulted in bringing

*Assistant Engineer, Department of Public Works, Borough of Manhattan, New York, N. Y.

From the Proceedings of the Fourteenth Annual Convention of the American Road Builders' Association.

to light places of unexpected congestion and afforded clues as to how the traffic can be diverted. It was found that, where the maximum number of vehicles per foot of width per minute exceeded 0.5, there was such serious congestion that a remedy needed to be applied. It was also found that where the maximum number of pedestrians per foot of width per minute exceeded 5.0, they flowed over the sidewalks into the roadway. When both these conditions existed, the street would need to be widened. So far, this difficulty has been obviated by clearing the sidewalks of stoops, railings, court yards, areas and other projections, thus affording additional space for pedestrians, and then widening the roadway to accommodate the suitable number of lines of travel, provided such widening did not produce an unduly congested condition for the pedestrian traffic. The traffic census has made the strongest kind of supporting data for promoting legislation for the foregoing work, and shows indisputably the need, or otherwise, of street widening.

The influence of the proportion of horse-drawn traffic on the kind of pavement, its grade, and alignment should be given weight. In cities with intensive traffic, where more than 75 per cent is motor traffic, sheet asphalt is, in the opinion of the writer, the pavement par excellence; if the traffic is evenly divided between rubber and iron tires, wood block stands out preeminently, while, for the slow moving, horse-drawn traffic, amounting to more than 50 per cent of the whole, close jointed granite blocks are eminently satisfactory, these limitations to be applied, of course, where traffic conditions are considered as the controlling factors in forming a decision.

The difference in traction between these three kinds of pavement, as indicated by tests shown in a pamphlet on "Tractive Resistance of a Motor Truck," by A. E. Kennelly and O. R. Schurig, may be represented by the following factors, which are averages of tractive resistances at a speed of 19 miles per hour.

Pavement	Tractive resistances in lb. per ton
Asphalt	19.0
Wood and brick	23.0
Granite	26.0
Macadam	22.5
Tar macadam	24.5
Gravel and cinder	26.5

The tractive resistance should, in the opinion of the author, be given much greater weight in the selection of pavements in cities than is usually accorded them, for the following reasons: It will hardly be questioned that motor trucks, in the cities at least, will soon be in almost universal use, and when this is a fact the consumption of fuel will undoubtedly be carefully examined into and smooth, light traction surfaces demanded for economy of operation. Today, with the numerous passenger cars in use, scant attention is paid to ease of traction, grade, or consumption of gasoline, and a scenic highway is at times preferred to the shorter utilitarian route for which there is going to be an urgent demand by the motor trucks, especially in rural districts.

A few figures as to the growth of the motor truck in New York State are presented. A report of the Secretary of State states that it is estimated that auto-trucks traveled over State and country highways in 1915, for 40 weeks in the year, 14,700,000 miles, and that these trucks operated 60,200,000 ton-miles. The number of auto trucks in New York State in the last three years is as follows:

1914	17,141
1915	20,880
1916	34,653

There were in New York City in 1916 about 21,000 motor trucks. In addition, there are more than 100 routes in the State over which heavy motor buses are operating, nearly all of which are less than three years old.

Tables such as the foregoing will soon need careful revision, because of the weights and the speeds at which these trucks move. The preparedness movement has served to draw attention to the fact that it is desirable to consult the War Department as to the loads to which roads and bridges are likely to be subjected for military purposes.

The increase in the destructive effect of this traffic points to the need of much harder and more durable surfaces than have been afforded by the penetration method of construction—surfaces constructed with one course of run of crusher stone with bitumen; sand asphalt roads; broken stone, sand and bitumen roads; carpeted macadam, and other kinds of light traffic bituminous construction.

Recognition of the destructive effect of auto truck travel has recently led to a readjustment of the registration fees to a higher scale in New York State. Experience with the situation is necessary, in order to determine the exact number of commercial vehicles which may traverse economically certain types of road.

Traffic Census in the Regulation of Traffic

The traffic census finds its application to the regulation of traffic in large cities where congestion is imminent or actual. The Borough of Manhattan has found it necessary to establish 29 streets as one-way traffic streets. These are located largely in the mercantile and theater districts. Three of them are theater streets, with a one-way rule applying one-half hour before and after the termination of performances.

A determination of the amount of traffic in all the streets of any section of a city should indicate where a diversion of the flow is desirable. So far as the writer has been able to ascertain, but one study* of the flow of traffic has been made, that being in the city of Bridgeport, Conn. The writer believes that such studies are highly important where there is intensive traffic on a gridiron system of streets, to the end that alternate traffic routes may be laid out by widening, paving, regrading or otherwise improving, so that congestion may be avoided and the orderly transaction of business facilitated.

A number of the large express companies and other corporations now route their vehicles, and have a regular patrol which keeps them constantly informed of their location. A study of the flow of traffic in a large, busy city may offer some difficulties, but would be helped out by instances such as the foregoing. In the Borough of Manhattan, the Fifth Avenue Association has influenced traffic on that avenue by encouraging merchants and others to exclude commercial traffic from this distinctly retail mercantile and residential thoroughfare, so that there is now less than 2 per cent of horse-drawn vehicles of all kinds. This association makes its own traffic counts and studies traffic conditions quite independently of the city, and is in a position to make valuable recommendations as to the policy to be pursued. It was suggested to the Police Department that more time be given to the north and south traffic than to the east and west, with the result that about 45 minutes of the hour are devoted to the longitudinal travel, while the crosstown traffic takes up the remaining 15 minutes. It has been proposed to divert the through traffic of Fifth Avenue to a parallel

*Alfred S. Miller, *Engineering News*, January 21, 1916.

avenue, thus affording some relief to this much congested thoroughfare.

Regulation of Pedestrian Traffic

It is daily becoming more apparent that if the vehicular traffic is to proceed with reasonable speed, say 8 miles an hour, on our busiest streets, it will be necessary to regulate the pedestrian traffic as well. It was found that the average time taken by a woman crossing Fifth Avenue—which has a width of 55 ft.—was 11½ seconds. In the busy hours, 6 vehicles would pass in that time, rendering the crossing difficult and dangerous. There is nothing to prevent a pedestrian from crossing the street at any time he may elect to do so, but he certainly needs to be told when, if the number of accidents which happen is a criterion.

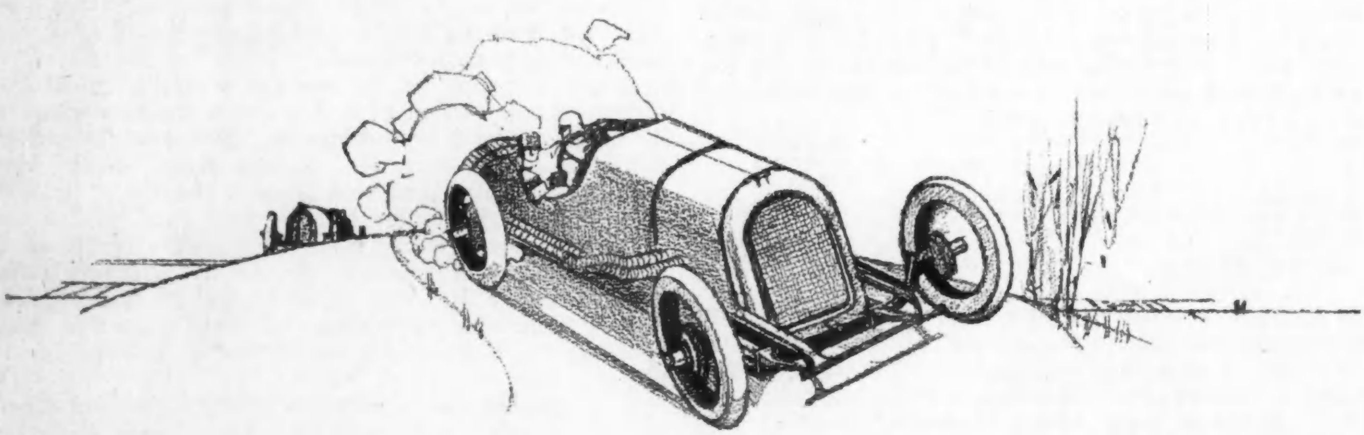
The subject matter of traffic regulation can be only touched on at this time. State-wide cooperation, to the end that uniform regulations may be drafted and legislated into laws, is much needed. Attention is directed to the proposed regulations of the State Bureau of Municipal Information of the Conference of Mayors of New York State, embodying the ideas of those most interested in that State. It does not, however, cover the matter of the regulation of the size, weight or construction of the vehicle itself, which is of great interest to the highway engineer.

What the Census Should Include

The traffic census should include observations as to the direction of the flow of traffic, such as left-hand turns; number of vehicles emerging from, or entering side streets; routes of mail trucks, wandering cabs and other vehicles, as well as a knowledge of the various classes of vehicles, if the congestion features of traffic are to be studied. The points at which the count should be taken are worthy of study, and this study is best made by plotting bands of different colors and widths along the roads or streets where the census has been taken. Work of this kind has an intimate relation to building district restriction plans, and to the city plan generally.

Uniformity in methods of taking and recording counts, and in the assignment of weights, is much needed for comparisons in different sections. Some office work can be saved by the use of standardized forms, and the writer would suggest that this matter be given attention by the committee on standards of this society, and that the cooperation of other engineering societies be sought in making such forms.

In conclusion, the writer would direct attention to the fact that the traffic census has a wide application to city work in the selection of pavements, street widening, the removal of encroachments, traffic regulation, fixing values of property, opening of new or extension of old streets, operation of street railroads and buses under franchises, determination of the amount of wear of various kinds of pavement under known weights of travel, regulation of the dimensions, weights, etc., of vehicles, and the determination of a paving policy.



Current Standardization Work

THE Division meetings scheduled for the rest of this year are as follows:

Aeronautic Division, Nov. 26, S. A. E. Headquarters, New York.

Chain Division, Dec. 6, S. A. E. Headquarters, New York.

Lighting Division, Nov. 15, S. A. E. Headquarters, New York.

Miscellaneous Division, Dec. 1, Congress Hotel, Chicago.

Motorcycle Division, Dec. 3, Wisconsin Hotel, Milwaukee.

Tractor Division, Dec. 5, Empire Room, Radisson Hotel, Minneapolis.

The Motorcycle Division, as appointed by the Council, consists of Wm. S. Harley, chairman, C. O. Hedstrom, Frank W. Schwinn, and R. F. Rogers. The Stationary and Farm Engine Division is made up of Charles Kratsch as chairman, Theodore Menges and others whose names will be announced later.

Below is described a report of recent meetings of the Aeronautic, Lighting and Motorcycle Divisions. An outline of the work done at a meeting of representatives of the Aeronautic Division, the International Aircraft Standards Board and the British Aeronautical Inspection Department also follows. Several reports presented by committees have been included in the abstract of the meeting.

Aeronautic Division Meeting

A MEETING of the Aeronautic Division was held at the Bureau of Standards on Oct. 28 and 29. Those present were: Chas M. Manly, chairman; C. S. Ash, E. W. BeSaw, Clarence Carson, John R. Cautley, Herbert Chase, J. G. Cooley, Chas. W. Davis, H. C. Dickinson, F. G. Diffin, E. H. Ehrman, Grover Farnsworth, J. C. Ferguson, Lieut. Col. L. E. Goodier, Jr., J. E. Hale, P. M. Heldt, F. R. Hoyt, O. H. Jobski, J. B. Johnson, R. B. Jones, J. D. Kent, H. E. Krause, A. D. T. Libby, W. M. MacNichol, J. F. McClelland, Capt. Stafford Montgomery, H. E. Morton, O. W. Mott, Capt. Wm. C. Oker, Lieut. C. B. Pfeifer, Anderson Polk, L. V. Pulsifer, O. C. Rohde, Chas. Schenck, Wm. B. Stout, J. D. Tew, F. S. Thompson, J. C. Tuttle, J. E. Vail, Percy H. Walker, Harold F. Wood, G. B. Wright, and Standards Manager M. W. Hanks.

Changes in Dope Committee Report

Minor changes in the Dope Committee report submitted at the last meeting of the Aeronautic Division were presented by Chairman Smith. This report was published on page 271 of the October JOURNAL.

Paragraph No. 4, under cellulose acetate dope, has been changed to read:

Effect on Tensile Strength and Weight—Four coats, or an equivalent of the dope, 48 hours after application, must increase the tensile strength of linen fabrics not less than 25 per cent of the original average strength of warp and filling and of cotton fabrics not less than 15 per cent. The increase in weight should not be less than 2 oz. nor greater than 2.75 oz. per square yard of doped fabric.

The specification for tetrachlorethane, paragraph No. 7, has been changed to read:

Tetrachlorethane—Dopes containing tetrachlorethane will not be acceptable for Signal Corps repair work, but will be permissible in factories provided with adequate ventilation.

The exposure test specification, paragraph No. 11, has been changed slightly. The sentence, "This test shall be made comparatively with a dope," has been changed to be, "This test shall be made in duplicate and comparatively with a dope." In the acidity test it has been suggested that twenty-fifth normal caustic soda instead of tenth-normal be used for titration.

Similar changes have been made for the nitrate dope paragraphs, effect on tensile strength and weight, exposure and acidity tests. Other changes are, under acidity: "No mineral acids shall be present in the dope," instead of "may be present," "and the amount of free organic acidity figured as acetic acid may not exceed 0.5 per cent." Paragraph No. 6 now reads:

Cellulose Nitrate—The cellulose nitrate used in the manufacture of dope shall be purified and given a negative potassium-iodide test at the end of twenty minutes, according to the standard method of the Bureau of Standards.

The inflammability of dope was the chief point brought out by Colonel Goodier in the discussion of the report. The danger of fire being transmitted to the wing from the engine, in case of a back-fire, is a possibility that all fliers have to face, and of which they are much afraid. It was Colonel Goodier's opinion that the chief value of dope was in the lowering of skin friction. The point to guard against, however, is not to increase the weight so as to offset any advantage gained by the decrease in skin friction. The increase in the weight decreases the performing ability of the machine, therefore making the danger of not bringing in information of tactical value greater than if the machine was lighter and the wings unprotected by dope.

Another important point in using a dope is to protect the interior structure of the wing from the weather. Without the application of dope the metal fittings in the interior of the wing deteriorate much more rapidly, and the life of the covering is materially shortened. It was suggested that the wing structure should be examined at certain definite periods, in the same manner as engines are now. The conditions of the wing could be ascertained very well from their behavior in the air and by testing their rigidity.

Varnish—The final report of the Varnish Committee was given at the last meeting, so that Chairman Walker merely stated that the Committee was working on enameled and colored coatings, and requested information concerning colors desirable for obscuring airplanes in flight. Mr. Hanks was instructed to obtain the opinion of the Army and Navy officers on this subject. It was pointed out that it was desirable to keep the number of colors as low as possible on account of the difficulty of making satisfactory airplane varnish when mixed with color pigments.

It was said that the varnish specifications do not include the increase in weight per square yard of fabric

after being varnished. This increase was included in the dope and fabric specifications, and it was deemed advisable that a similar limitation be put upon varnish. The Committee will consider this point.

Engine Weight Specifications—The report of the Engine Weight Specification Committee, as submitted at the last meeting, and published on page 275 of the October JOURNAL, was accepted by the Division.

Glue Specifications—These specifications, as submitted at the last meeting for consideration, were accepted by the Division.

Heat Treatment of Frame Joints—It was the sense of the meeting that complete specifications on this subject should be drawn up as soon as possible. The Committee appointed has to decide what treatment should be given both to tubing joints before they have been welded or brazed and to joints in other forms.

Several joints have been treated by simply using a soft gas flame instead of the oxy-acetylene flame and bringing the joints at which the heat is localized up to a bright cherry red. This is necessary in order to relieve the strain and refine the material as much as possible. Other joints have been welded and put into the heat-treating oven, raised to a temperature of 1650 deg., quenched, and then drawn at 900 deg. From the stand-point of joint treatment the latter form seems more preferable. In case of a framework where the tubes are long it is a serious problem to heat-treat the entire frame on account of danger of warping. It seems desirable that a method be developed for refining the grain at the joints without heat-treating the entire frame.

Hand Air Pumps.—In general, hand air pumps were said to be satisfactory, but the pipe fittings and the valve could be improved upon. They are continually coming loose and leaking, on account of the excessive vibration. Standards Manager Hanks was directed to call the attention of the manufacturers of hand air pumps to the advisability of devising some positive locking scheme for the fittings.

Marking of Control Levers.—On account of recent rapid developments, it was not considered desirable to restrict design by recommending uniform movement of control levers. It was suggested, however, that all control levers be marked so as to indicate their purpose and direction of control.

Gasoline Hose.—In the two following specifications the best British practice is followed with the changes necessary to adapt it to the commercial methods in this country. The specifications are in no way inferior to those of the Royal Aircraft Factory. The specification Type No. 1 is essentially No. 114B of the Royal Aircraft Factory. Type No. 2 hose is of different construction; an inside layer of fabric supported by a coil of thin iron wire is the principal difference. It was stated that the purpose of this construction is to prevent small particles of the rubber hose flaking off and getting into the gasoline and to insure a continuous open passage. This type of hose has given satisfactory service in garages and probably would in airplane service. The Committee called attention to the fact that these specifications, as well as those of the R. A. F., are deficient in the following points:

The weight per foot is not specified. This will necessitate knowing the sizes required for airplane service and is important in view of minimizing the weight of the airplane.

The specifications do not state the pounds pull required to separate the plies after they had been treated with gasoline. The present wording "stripping with difficulty" is not specific and leaves too much chance for error to the judgment of the testing department.

In order to permit quick adjustment, the hose, type No. 2, should slip easily over a tube whose outside diameter is larger than the inside diameter of the hose.

The objections will receive further consideration by the Committee and will be reported on at the next meeting. Rubber tubing has been produced commercially that corresponds in every way to the specifications reported by the Committee. It was understood that the Goodrich Company will make up a number of 50-ft. lengths to be sent out for actual service tests.

GASOLINE HOSE SPECIFICATIONS

The committee appointed to consider gasoline hose specifications held a meeting Oct. 26 at Akron, those present being: H. S. Doty, R. J. Stokes, M. R. Riddell, P. L. Wormeley, J. B. Tuttle and Messrs. Kilburn, Kimock, Wolf, Noble, Somerville and Clark. The following report was formulated and accepted at the Aeronautic Division Meeting:

Type No. 1, Rubber Tube

Construction—The gasoline hose must consist of rubber and cotton constructed in the following manner: The quality of the finished hose must be uniformly good throughout.

Inner Tube—The inner tube is to be made of rubber free from flaws or cracks and of a quality conforming to the conditions laid down in this specification. When of an internal diameter of ¾ in. or less, the inner tube must be seamless. Tubes of larger internal diameter may be made from sheet rubber consisting of at least two complete layers.

Cotton Plies—The cotton shall consist of either braided or canvas plies and shall comply with the following table:

Internal Diameter of Hose, In.	Number of plies
Up to ⅝	Not less than two
11/16 to 1½	Not less than three
Greater than 1½	Not less than four

Outer Cover—An outer cover is to be made of rubber of the same quality as that used for the inner tube, and of good workmanship and finish.

Dimension Limit—The internal diameter of the hose must not vary more than plus or minus 3 per cent of the internal diameter stated on the order.

Length of Hose—The contractor, when quoting or when acknowledging an order for this class of hose, must state the lengths in which it can be supplied. The hose should be supplied in the maximum possible lengths.

Flexibility—By "flexibility" is meant the capacity to bend without kinking. When hose of internal diameter Y (see table) is bent around a cylinder equal to X times the external diameter of the hose, the external diameter of the hose must not increase or diminish by more than 10 per cent.

Internal Diameter of Hose Y	X
Less than ½ in.	8
½ in. to ¾ in.	12
13/16 in. to 1⅛ in.	14
Above 1⅛ in.	16

The hose, after having been filled with gasoline for two hours, must withstand a minimum internal hydraulic pressure of P lb. per sq. in. (see table), depending upon

the internal diameter D of the hose, without showing defects.

Internal Diameter, D, in.,	Minimum Pressure, P, lb. per sq. in.
Up to ½ inclusive	160
9/16 to 1 inclusive	140
1 1/16 to 1½ inclusive	120
1 9/16 to 2 inclusive	100
Above 2 inclusive	80

Rubber—No organic matter other than Para or plantation rubber shall be used in the preparation of this hose. The percentage of rubber shall not be less than 32 per cent. The amount of free sulphur in either the tube or the cover shall not exceed 1 per cent.

Dry Heat Test—A 3-in. piece of hose, after having been placed in an air oven at 132 deg. cent. for 2 hr. must show, when cool, no tendency to crack, and must not be "tacky."

Permeability Test—A 14-in. length of hose is held vertically and plugged at the bottom. The upper end is fitted with a glass tube about 18 in. long. The hose so arranged is filled with gasoline to a head of 12 in. above the top of the acting length of the hose. The acting length of the rubber hose is 12 in. The upper end of the glass tube is loosely closed with a cork. The specific gravity of the gasoline used in this test should be between 0.710 and 0.725 at 60 deg. fahr.; 65 per cent of it must distill at over 100 deg. cent. from a distillation flask when the bulb of the thermometer is just below the side tube.

During the first 24 hr. the level of the gasoline will fall comparatively rapidly. The gasoline loss is replaced by frequent additions from a known volume of gasoline, care being taken that the level of the gasoline in the glass tube does not fall by more than 3 in. at any time. The test is to last for 72 hr. and the loss of gasoline during the third 24 hr. must not exceed 100 c.c. per sq. ft. of the original internal surface of the hose.

Immersion in Gasoline—A 3-in. piece of the hose is boiled for one hour (using a reflex condenser) in gasoline similar to that used for the permeability test. The gasoline is allowed to cool. Twenty-four hours later the test piece is removed from the gasoline and examined without delay, as follows:

The internal diameter at the point of greatest constriction is measured by means of rod gages. From this measurement the area of the bore is calculated. It must not differ from the original by more than 25 per cent.

The test piece is then cut longitudinally into halves, and the adhesion between rubber and cotton carefully tested. The adhesion must be of such a character that the rubber can be stripped from the cotton by hand only with difficulty.

Immersion in Oil—A 3-in. piece of the hose is immersed in oil, approved by purchasing office, at a temperature of 100 deg. cent. for 8 hr., and for a further period of 24 hr. at ordinary temperature. The oil is then wiped from the surface of the hose. The decrease of internal diameter shall be less than 10 per cent.

The flexibility and elasticity of the rubber must not be diminished and there must be no tendency of the rubber to separate from the cotton.

Test Pieces—The purchaser will decide where the tests are to be carried out. All test specimens are to be cut in the presence of the inspector and they are to be marked as he may direct. For the purpose of testing, a representative sample will be cut from each 1000 ft. of hose or fraction thereof, and the tests will proceed in accordance with the instructions from the purchasing office.

Rejections—If any sample fails to comply with any of the above tests, the hose represented thereby will be rejected.

Marking—Accepted and rejected material must be marked as directed by the inspector.

Depreciation—The contractor must bear the cost of the depreciation in value of any rejected material on account of test pieces being cut therefrom.

Rejected Material—The contractor must not supply any material which has previously been rejected by any government department, without giving full written particulars of the previous rejection to the inspector who is inspecting this specification.

Type No. 2, Cotton Inside Reinforced with Wire

The specifications for type No. 2 are similar to type No. 1 with the exception of the second paragraph, which is as follows:

Inner Tube—The inner tube shall consist of a canvas tube supported by a helix of oil-tempered steel wire of not less than 0.020 in. diameter, spaced not less than five turns per inch. The rubber tube shall be placed between this inner cotton tube and the cotton plies specified below.

Spark-plug Shells

Spark-plug shell dimensions as recommended by the Aeronautic Division are given in Table I. The smallest root diameter of threads is 0.620 in., whereas the minimum for B is 0.625 in. It would seem advisable to reconsider this, as it might cause interference.

On account of the discrepancy between the standards of manufacturers, all makers of spark-plugs and of standard gages, will be urged to adopt at the earliest possible moment the sizes and tolerances accepted by the Society at the June (see July JOURNAL) meeting.

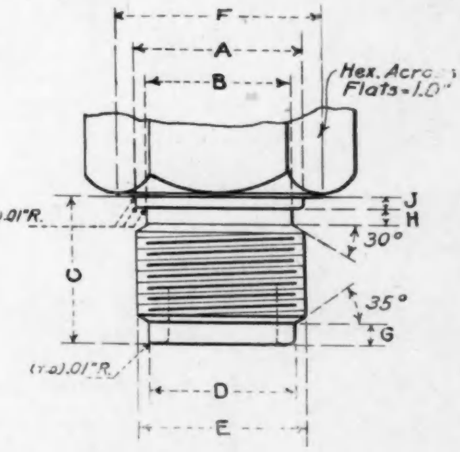


TABLE I—SPARK-PLUG SHELL DIMENSIONS

		A	B	C	D	E	F	G	H	J
Max.	In.	0.710	0.664	5/8	0.625	0.708	..	..	5/64	3/64
	Mm.	...	...	..	...	17.97	..	..	..	..
Min.	In.	0.706	0.625	9/16	...	0.703	15/16	3/32	..	..
	Mm.	...	...	..	...	17.85	..	..	..	..

These spark-plug tolerances and sizes have also been adopted by the British Engineering Standards Committee. Since any sizes beyond the limit specified will be

rejected, it is essential that manufacturers work as near the upper limit on male threads and the lower limit on female threads as possible. Particular attention should be called to pitch diameters.

REPORT ON TACHOMETER DRIVE

The committee on tachometer drive, composed of F. G. Caldwell, Clarence Carson, Major J. G. Vincent, and H. C. Dickinson, recommended, in cooperation with representatives of the War Department, the following:

The upper or instrument end of the shaft shall have a square socket, made integral with a shoulder that forms a thrust bearing.

The lower or engine end is to be finished with a cylindrical end with a single integral key.

The casing is to be of flexible metallic tubing, covered with whipcord braid and impregnated to prevent oil leakage; similar to sample, or covered with other material that will be equally flexible, oil tight and free from stretching and of no greater weight than the whipcord-braid covering casing. The outside diameter of casing to be over braid to be about 7/16 in.; the inside diameter of casing to be about 1/4 in. The ends of the casing are finished alike, as shown in the accompanying sketch. The sockets covering the whipcord braid are screwed in place and set with shellac or other suitable material to form an oil tight and permanent connection.

The shaft end at the engine is drilled and slotted to fit the tachometer-shaft end, allowing for at least 1-in. end play. More play than this may be required where the drive shaft is more than 6 ft. in length, the amount to be determined experimentally.

The drive-shaft is to be of helical wire-wound construction, with core wires.

The tachometer spindle is to be finished square to fit the square socket on the drive-shaft.

The drive-shaft will rotate at one-half crankshaft speed.

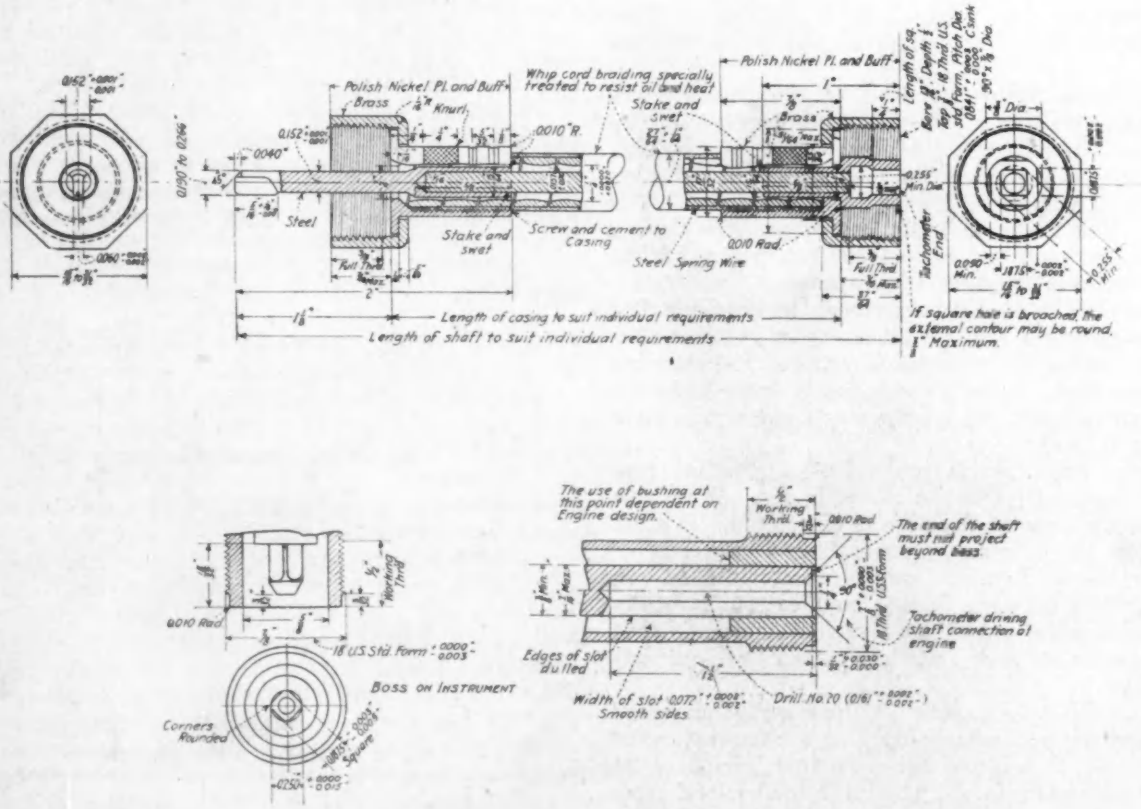
The size and contour of exterior circumference of end nuts is to be optional, but a 15/16-in. octagon is recommended.

The dimensions and details are given on the accompanying drawing.

In discussing the report on this subject it was pointed out that other materials than the whipcord-braid specified are satisfactory. The report should be changed to include any material that will be equally flexible, oil tight, free from stretching and of no greater weight.

Airplane Wheels—The report of the Wheel Committee as presented by Mr. Hale was accepted by the Division with a recommendation that spokes, spoke lacing, the tolerances of hubs and other parts as well as stream-line covering and methods of attaching be referred to the committee for further consideration. The report of the committee recommended, with certain qualifications, the adoption of the Palmer wheel. This wheel is favored by the Signal Corps, as possessing points of superiority over the conventional American type. The patent situation, of course, may offer objections to standardization.

The recommended tire sizes are 700 by 75, 700 by 100, 750 by 125 and 800 by 150 mm. The sizes 700 by 100 and 750 by 125 are to fit the same wheel. Table No. II gives the wheel sizes in inches and millimeters and the corresponding hub dimensions recommended by the committee. (See page 334.)



DETAILS OF TACHOMETER DRIVE RECOMMENDED FOR CONSIDERATION OF AERONAUTIC DIVISION

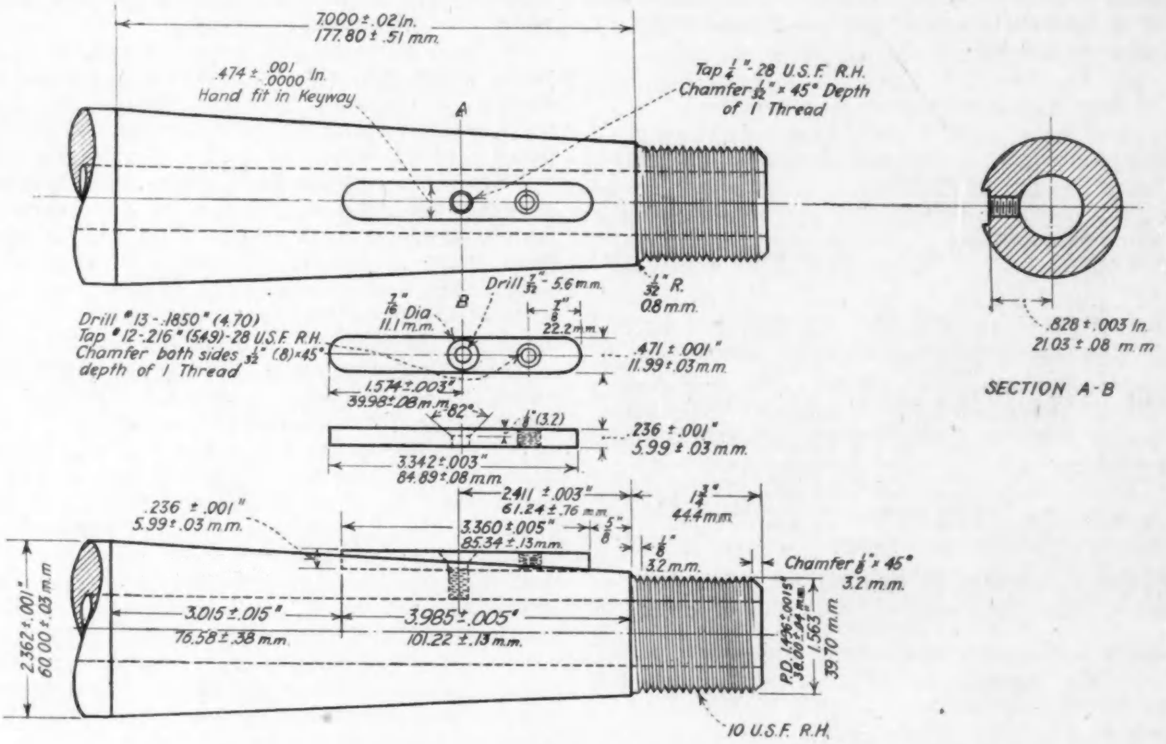


FIG. 1—PROPELLER SHAFT-END FOR ENGINES DELIVERING LESS THAN 200 HORSEPOWER

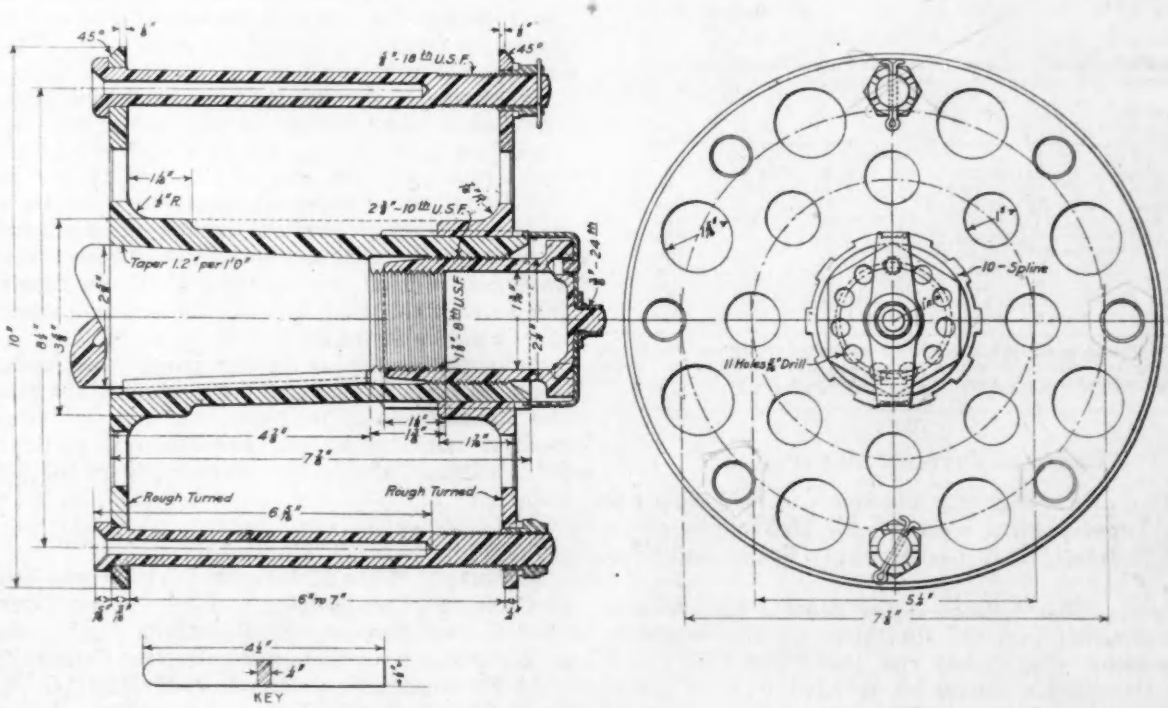


FIG. 2—PROPELLER SHAFT-END FOR ENGINES DELIVERING MORE THAN 200 HORSEPOWER

Aeronautic Safety Belts—A committee was recently appointed to consider standardization of aeronautic safety belts and consists of Lieutenant Colonel Goodier, Captain Oker, E. G. Diffin, Captain Montgomery, J. B. Johnson, Clarence Carson and Standards Manager M. W. Hanks.

It seems that the Army and Navy belts are similar, the principal difference being that of the catch. The Army belt is worn around the thighs, whereas the general practice is to wear the Navy belt around the waist. The method of tightening is also dissimilar. Final decision will be put off until a mutual satisfactory design of belt has been made.

Propeller Shaft and Hub—The committee on this matter met on Oct. 30, those present being Lieut. Commander A. K. Aitken, C. B. King, F. W. Caldwell, and Standards Manager M. W. Hanks. It was the consensus of opinion at the meeting that a taper of 1 to 10 should be adopted for all engines and that the shaft end for engines up to and including 200 hp. should be in accordance with Fig. 1, which is similar to the present S. A. E. shaft-end. This

shaft size is now used on the Hispano-Suiza engine and others. The construction in Fig. 2 was recommended for engines of over 200 hp.

TABLE II—AIRPLANE WHEEL AND HUB DIMENSIONS

WHEEL		HUB					
		BUSHING					
		DIAMETER				Length	
Mm.	In.	Outside Running		Inside Axle Diam.			
700x 75	28x3	....		....		....	
700x100	28x4	1.946 in.	−0.002 −0.003	1.751 in.	+0.0098 −0.0000	7.008 in.	+0.013 −0.028
		49.43 mm.	−0.050 −0.075	44.45 mm.	+0.25 −0.0000	178 mm.	+0.33 −0.071
750x125	30x5	1.946 in.	−0.002 −0.003	1.751 in.	+0.0098 −0.0000	7.008 in.	+0.013 −0.028
		49.43 mm.	−0.050 −0.075	44.45 mm.	+0.0250 −0.0000	178 mm.	+0.330 −0.710
800x150	32x6	2.579 in.	−0.002 −0.005	2.165 in.	+0.0098 −0.0000	7.283 in.	+0.013 −0.028
		65.5 mm.	−0.050 −0.130	55 mm.	+0.2500 −0.0000	185 mm.	+0.33 −0.710

Washers—The Committee on this subject submitted for consideration, the bevel-washer dimensions given in Table III.

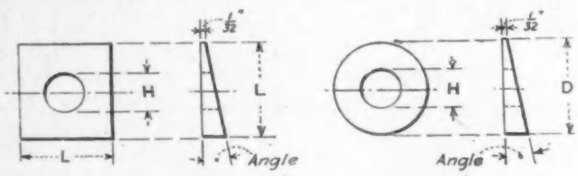


TABLE III—DIMENSIONS FOR SQUARE AND ROUND BEVEL WASHERS

Bolt Size or No.	*H*	*D*	*L*
4 (0.112)	31 (0.120)	3/8	3/8
6 (0.138)	26 (0.147)	7/16	3/8
8 (0.164)	17 (0.173)	15/32	15/32
10 (0.190)	8 (0.199)	1/2	15/32
12 (0.216)	1 (0.228)	9/16	17/32
1/4	17/64	5/8	17/32
5/16	21/64	11/16	21/32
3/8	25/64	3/4	21/32
7/16	29/64	15/16	7/8
1/2	33/64	1	7/8

NOTE.—Both sides must be flat and free from burrs. If the washers can be cut by shearing and without distorting the surface, this is permissible. Stock must be bright medium-carbon steel. Values of angle, 6, 12, 24, 36 deg. for all sizes.

LIGHTING DIVISION MEETING

A meeting of the Lighting Division was held Nov. 1 at Detroit. Those present were W. E. McKechnie, chairman; W. T. Jones, C. E. Godley, G. L. Sealey and R. S. Burnett.

Head-Lamp Illumination.—After general discussion it was recommended that the limitation on the height to which the beam of light may rise (see Sheet 38b, Vol. I, S. A. E. Handbook) should be changed to read: "Nor shall any portion of the direct reflected beam cone of light rise beyond the 75-ft. distance more than 12 in. above the center of the head-lamp."

Head-Lamp Nomenclature.—The definitions of head-lamp nomenclature have been approved by the Division for incorporation in data sheet form.

Head-Lamp Terminology.—The Division recommended that the suggested change of "Head-Lamp Lighting Terminology" to "Head-Lamp Lighting Nomenclature" be referred to the Nomenclature Division.

Head-Lamp Bulbs for Electric Vehicles.—The Division recommended that the standard focal length of electric incandescent lamps for both electric and gasoline propelled vehicles should be 1¼ in.

In the discussion Mr. Sealey stated that G-16½ (25 watt) lamps were the smallest size in general use by the electric vehicle manufacturers, because the smaller size bulbs will not stand the high wattage. For gasoline propelled vehicles, either the G-12 or G-16½ size can be used.

Filament Position Tests.—Mr. Bauder's report regarding the relative position of the filament to the lamp-base axis and the results of tests of 800 lamps taken from stock in process of manufacture from four factories (200 bulbs from each factory) was presented. None of the lamps had been tested previously in the factories for the filament positions.

In making the tests the lamps were held in a socket. A screen with a square aperture was set up at a short distance facing the lamp. Beyond this another screen was set up parallel to the first, but at such a distance that the reflection of the lamp filament through the aperture on the first screen was shown enlarged three times on the second screen. The second screen was marked with a rectangular space which would just inclose the reflection of a perfect filament. If the position of the filament varied over or under the nominal focal length of the lamp, the amount of such variation could be measured by the distance the reflection of the filament extended above or below the rectangular inclosure on the screen, the measurement on the screen being three times the actual variation of the filament.

The measurement of variation of the center-line of the filament with the axis of the lamp base could be measured by rotating the lamp in the socket and measuring the variation from side to side of the location of the filament image on the screen.

The tests of the 800 lamps showed that 94 per cent of the lamps came within factory limits of the standard focal length of 1¼ in. In the variation of the lamp filament relative to the axis of the base, 93 per cent of the 800 lamps tested were within factory limits.

The customary practice among lamp manufacturers, because of the difficulty in manufacturing, is to allow a variation of 1/16 in. either way in the focal length of the lamp or in the variation of the center-line of the filament relative to the axis of the base.

In a discussion as to the position of the "V" filament, in type "C" lamps, it was stated that the plane of the filament should be horizontal with the lamps in the position with the axis of the lock-pins vertical and the point of the "V" filament should fall on the axis of the base.

MOTORCYCLE DIVISION MEETING

A meeting of the Motorcycle Division was held Oct. 30 at Chicago. The Division members present were: W. S. Harley, chairman; C. O. Hedstrom, R. F. Rogers and F. W. Schwinn. Others present were: George T. Briggs, T. C. Butler, Jr., F. C. Hecox, P. M. Heldt, G. A. Krauss, G. W. Morry, Frank B. Rodgers and T. J. Sullivan.

Spoke-Head Radius.—It was recommended by the Division that the dimension locating the spoke-head radius center be made 7/64 in.

Nipple Counterbore.—It was recommended that the depth of nipple counterbore be changed from 5/16 to 7/16 in.

Rim Depression.—The dimensions of rim depression shown in Fig. 1 were recommended by the Division. The value of this depression is that it permits a perfect spherical bearing surface for the nipple when assembled with hubs of various lengths and diameters. This was

not permitted by the former method of using a standard countersink. With this rim depression a standard rim can be used for all motorcycle wheels.

Motorcycle Rims.—A standard rim was recommended for motorcycle front, rear and side-car wheels. The

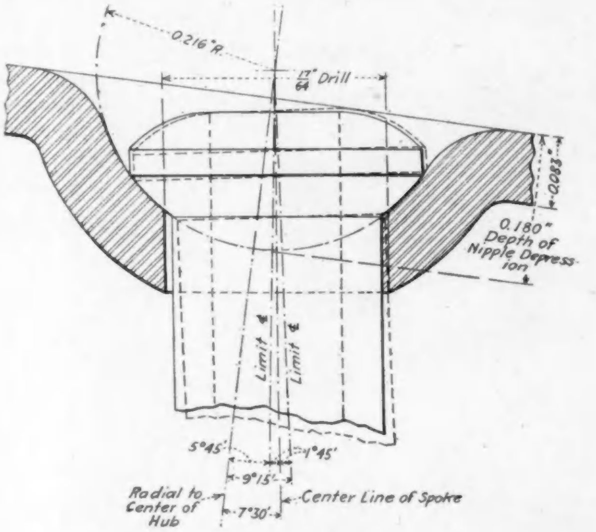


FIG. 1—MOTORCYCLE RIM DEPRESSION

tolerances for this rim are to be those of the Clincher Tire Manufacturers' Association.

Rear Hubs.—It was considered inadvisable to recommend anything on this subject on account of the great dissimilarity of wheel-hubs of the different machines. The subject will be reconsidered at the next meeting.

BOLT AND SCREW STANDARDIZATION

A meeting of representatives of the International Aircraft Standards Board, the British Aeronautical Inspection Department and the Aeronautic Division of the S. A. E. Standards Committee was held Nov. 1 at the Buffalo plant of the Curtiss Aeroplane and Motor Company, to unify the bolt and nut lists of the I. A. S. B. and the existing recommended practice of the Society. The following were present: F. G. Diffin, C. M. Manly, Capt. A. B. Rogers, E. H. Ehrman, F. G. Ericson, Lieut. A. H. Binyon, Major Pearce, C. G. Hill, Lieut. R. Cragg, S. G. Payne, Lieut. W. F. Prentice and Standards Manager M. W. Hanks.

With the exception of clevis pins, upon which no definite action was taken at the meeting, the following subjects have been accepted recently by both the I. A. S. B. and the B. A. I. D.

Plain Hex-Head Bolts.—Attention was called to the formula used in calculating the thickness of the bolt head which is one-half the nominal body diameter of the bolt plus 1/32 in. This formula proved correct for extended tests at the Curtiss plant early in the summer. It is also useful in calculating bolt heads larger than those listed at present. The B. A. I. D. list provides for a 1/8-in. head on bolts up to and including 1/4-in. body diameter, and above 1/4 in. it corresponds very nearly to the S. A. E. practice. For the sake of unity it was agreed to adopt the S. A. E. bolt-head thicknesses from 1/4 in. up, but that Nos. 8, 10 and 12 should be 1/8 in.

It was agreed to keep the thread end of the bolt rounded to a radius equal to the nominal diameter, as this gives the proper thread chamfer to prevent objectionable burrs; also that the minimum length of thread should be indicated and the maximum number of threads beyond the minimum should not exceed four. A table of thread lengths is to be inserted at the foot of the general table as follows:

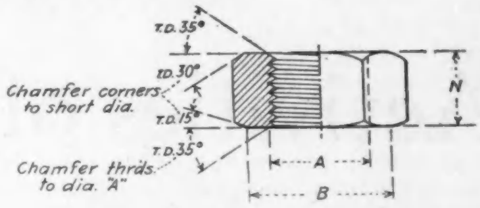
When body length L =	1/2	5/8	3/4	7/8	1	Over 1
Length of thread T =	3/8	7/16	1/2	1/2	1/2	3/4

Body Diameter Limits.—It was agreed that the nominal body diameter of the bolt should be the maximum and that the minimum should be 0.004 in. for from No. 8 to 1/2 in. inclusive, and 0.005 in. for 9/16 and 5/8 in. as shown in the Aeronautic Division report printed in the July JOURNAL. A note is to be added stating that "limits are for finished size, including plating or rust-preventing treatment when used." The Bureau of Standards has advised that plating should be 0.001 in. thick for rust prevention.

Ball Hex-Head Bolts.—The dimensions given for these bolts in the July JOURNAL were accepted, although the length of threads is to be the same as agreed upon for the plain hex-head bolts, and the same note relating to the limits of the bolt diameter is to be added.

Castle Hex Nuts.—It was agreed to accept the data for these nuts given on page 44 of the July JOURNAL.

Plain Hexagon Nuts.—The following dimensions for plain hexagon nuts were presented for consideration and will receive further attention:



DIMENSIONS FOR PLAIN HEXAGONAL NUTS

Size	Threads per In.	B	N
0.112 (No. 4)	36	0.250 (1/4)	0.094 (3/32)
0.138 (No. 6)	32	0.312 (5/16)	0.109 (7/64)
0.164 (No. 8)	32	0.375 (3/8)	0.125 (1/8)
0.190 (No. 10)	32	0.375 (3/8)	0.140 (9/64)
0.216 (No. 12)	32	0.438 (7/16)	0.156 (5/32)
0.240 (1/4)	28	0.438 (7/16)	0.187 (3/16)
0.313 (5/16)	24	0.500 (1/2)	0.233 (15/64)
0.375 (3/8)	24	0.563 (9/16)	0.281 (9/32)
0.438 (7/16)	20	0.688 (11/16)	0.328 (21/64)
0.500 (1/2)	20	0.750 (3/4)	0.375 (3/8)
0.563 (9/16)	18	0.875 (7/8)	0.422 (27/64)
0.625 (5/8)	18	0.938 (15/16)	0.469 (15/32)

A = Size of Bolt.
All Threads U. S. Form.
T.D. = Tooling Dimension.

B = Also Size of Hexagon.
Dimensions in Inches.

Officers of Pennsylvania Section in Session—Left to Right: T. Y. Olsen, Treasurer; A. K. Brumbaugh, Secretary; John W. Watson, Chairman; and B. B. Bachman, Member of Governing Board

Activities of S. A. E. Sections

THE Sections Committee appointed by the Council is now working on a number of matters connected with Section activities. In a report presented at the last Council meeting by Chairman B. B. Bachman of the Committee the statement was made that sections of the Society had been proposed in Syracuse, N. Y., Boston. Mass., the Pacific Coast, Eastern Canada and elsewhere, and that steps were being taken to find out whether strong organizations could be formed in such localities.

Recent Section meetings have been productive of a number of first-class professional papers, which will be published in early issues of the THE JOURNAL for the benefit of all the members of the Society. The paper on crankshaft design, given by Mr. Burkhardt at the Oct. 24th meeting of the Buffalo Section, is given in full in this issue, together with the accompanying discussion. It is expected that the discussion of airplane engines, presented by Mr. Sherbondy at the October meeting of the Cleveland Section, will appear in an early issue.

PAPERS AT SECTION MEETINGS

The next meeting of the Buffalo Engineering Society, at which the Buffalo Section will present the paper, will be held on Dec. 5, at the Hotel Statler, the subject and speaker to be announced later.

The Cleveland Section will meet on the 23rd at the Colonial Hotel, when G. Douglas Wardrop will speak on the subject of aerial warfare. At the December meeting on the 21st, J. E. Schipper will discuss, What the Automobile User Is Demanding of the Manufacturer.

The November meeting of the Detroit Section was held on the 16th under the auspices of the Planning and Mechanical Efficiency Division of the Industrial Research Committee.

INDIANA SECTION

The first regular meeting of the Indiana Section was held Oct. 26 at the Hotel Claypool, Indianapolis. In the absence of the chairman of the Section, Vice-Chairman C. S. Crawford presided. An announcement was made that Chairman F. A. Cornell had resigned owing to his removal from the city, that Frank E. Smith had resigned as secretary on account of his going to Washington to take up some Government work, and that C. E. Jeffers, who was elected treasurer at the last meeting of the Section, would be unable to accept the appointment. It was decided that Mr. Crawford would take care of the work of these three offices until they could be filled. In view of the fact that no arrangements had been made for a technical paper at the November meeting, it was decided

to hold simply a business session and to have the first technical meeting Dec. 7, when F. W. Gurney will give a paper on Some Fundamentals of Rolling Supports.

It was decided to have regular meetings the first Friday of each month, these to be held jointly with the Engineers Club of Indianapolis, with which the Section is affiliated.

The following committees of the Section were appointed: Research: D. L. Gallup, chairman; Chester S. Ricker and C. P. Grimes.

Papers: George Briggs, chairman; F. V. Hetzel, Mr. Mills, D. L. Gallup and Leroy V. Cram.

Entertainment: George Weidely, chairman, and Edward Reeser.

Membership: This committee will be appointed later and will consist of a representative of each automobile, tractor, aeroplane, truck and motorcycle factory in the territory covered by the Section.

A business meeting of the Indiana Section was held Nov. 2 at the Claypool Hotel, and it was decided to adopt the amendments to the Section Constitution relating to the change of name of the Society as recommended by the Sections Committee. The Nominating Committee of the Section is to nominate a new chairman, treasurer and secretary. A ticket to fill these vacancies will be presented at the Dec. 7th meeting, when Mr. Gurney's paper will be given.

Metropolitan Section

Aviation has developed so rapidly that possibly within the next four or five years the majority of the members of the Society will be concerned with the airplane. This idea was put forth by G. Douglas Wardrop, editor of *Aerial Age*, at the meeting of the Metropolitan Section held Oct. 25 at the Automobile Club of America. After summarizing present and future conditions, Mr. Wardrop took up the history of the airplane, beginning with the Wright machine of 1904.

Moving pictures were shown of the Handley-Page twin-engined machine and also of the Standard Aero Corporation factory. Other slides showed airplanes, dirigibles, observation balloons and kites in action.

In conclusion, Captain Boor of the British Aeronautic Inspection Department gave a short talk describing his personal experiences. Both Captain Boor's and Mr. Wardrop's remarks are summarized elsewhere in this issue.

The November meeting of the Metropolitan Section will be held on the 22nd at the Automobile Club of America, when W. P. Deppé will give a paper, Solving the Gasoline Problem. Invitations to attend the meeting have been extended to carburetion, lubrication and automotive engineers as well as to Government officials, and it is expected that a valuable discussion of the present difficulties and future possibilities of the fuel situation will be brought out.

Mid-West Section

The October meeting, which was held on the twenty-sixth, was devoted to the discussion of the Society meeting, which is to be held in Chicago in February. The Section is actively at work, and expects to make this meeting one of the most important ever held by the Society. Plans are being made to hold the November meeting on the 23rd at the Chicago Automobile Club. A program is being arranged dealing with the war work of the Society, details of which will be disclosed later.

Minneapolis Section

The November meeting of the Minneapolis Section was held at the Radisson Hotel, Minneapolis, and was devoted to a discussion of proposed rules for tractor demonstrations. The December meeting will be held on the 5th at the same place, and will be devoted to tractor starters. A large attendance is anticipated, inasmuch as the Tractor Division of the S. A. E. Standards Committee will meet on the 5th in Minneapolis at the office of the Section in the Plymouth Building.

Pennsylvania Section

On Oct. 25 the Pennsylvania Section held the first of its 1917-18 meetings, which are to be devoted wholly to the elements in car construction affecting easy riding. At each of these monthly meetings it is planned to take up and thresh out to a finish just one of the several elements bearing on the riding qualities of passenger car, ambulance or truck.

The paper at the first meeting was given by Walter C. Keys, chief engineer of the Standard Parts Company and was illustrated by many slides showing the action of vehicle springs as recorded by Mr. Keys' unique photographic method.

John Wilkinson, vice-president of the H. H. Franklin Manufacturing Company, gave details of some extremely valuable spring experiences. Then started the general discussion in which participated the representatives of many of the large spring interests of the industry.

It seemed to be the sense of the meeting that a vehicle spring should have as low a rate as possible, that is, be as "soft" as possible in order to absorb and not transmit road shocks and should be provided with adequate means for damping the recoil only.

It was said that a rusty spring, because of the extra friction thus set up, materially aids in damping the recoil, but also has the detrimental effect, owing to this same extra friction, of stiffening the spring against compression; this is equivalent to a spring of a higher rate. This stiffening is an aid to riding at higher car speeds, because of otherwise excessive recoil at such speeds, but it interferes with easy riding at lower speeds and therefore cannot be looked upon as a solution. Such stiffening results in transmitting more and absorbing fewer of the road shocks.

The conclusion therefore was that damping means within the spring itself were not desirable because any such means are bound to affect the action of the spring in both directions. Thus to dampen or stiffen the spring in the compression direction naturally destroys its ability to compress rapidly and absorb shocks upon striking the road.

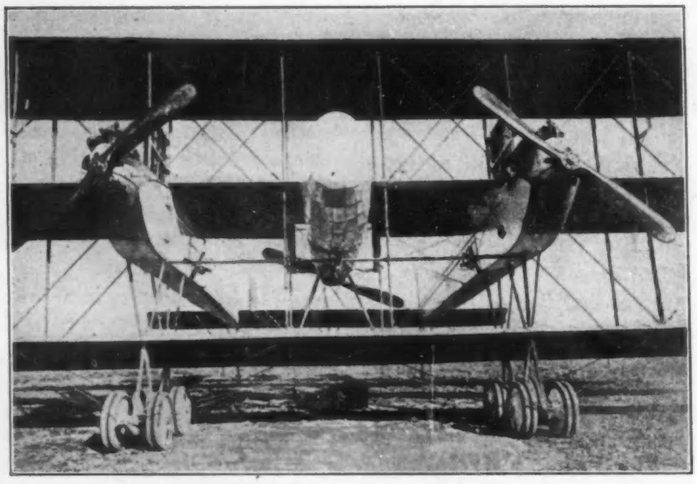
It was the further sense of the meeting that a multi-leaf spring was probably preferable to a spring of fewer leaves because of its softer action and greater range. The added friction resulting from the sliding of many leaves was also shown to be beneficial in a degree in minimizing recoil as compared to a spring having fewer leaves, but the friction thus set up could by no means be considered an adequate check for the recoil.

At the November meeting, which will be held on the 22nd at the Engineers Club, Philadelphia, it is expected that J. E. Hale of the Goodyear Tire and Rubber Company will discuss, Size, Inflation Pressure and Construction of Tires as Affecting Easy Riding. An invitation has been sent to all tire manufacturers to have some representative present to discuss the paper.

HAMPTON TO WASHINGTON VIA CAPRONI

IT WAS just a rocker arm, clicking away just five feet to my right, but it meant a whole lot. I watched it with interest, and looking the other way saw more of them on another engine ten feet away on my left. Back of me was another engine and some more rocker arms. However, this one opposite seemed to be the one I should watch. It was working all right.

Taking my eyes off it for a moment I looked down. The ground was 8000 feet below, laid out like a faded green plaid shawl on a far-away floor, while far ahead was a postage stamp some one had dropped on the shawl. The pilot ahead saw it, and, waving back to us, pointed down. The postage stamp was Washington. We were about to arrive. I looked again at the rocker arm. It was tapping away as pleasantly as a debutante's foot on the D. A. C. dancing floor. I was glad.



Caproni Triplane Driven by Three Engines

White clouds appeared, and seeing that they were on our level we dropped a thousand feet and sailed under them. Finding they were scattered we drove up again, all three engines roaring with delight, while the eight other passengers sat open-mouthed at their new wonder. We drove up and up, picking our way between the soft whiteness of the cloud banks as one would drive around and about bushes in a park; picking the open spaces and sky road until we were above the clouds again and at our 8000-ft. level.

Coming out from over a larger cloud than usual we saw the postage stamp again on the green background, and this time a white speck, the dome of the Capitol. We wondered why we didn't start down, but on we went until directly over the city.

I looked at the rocker arm. It was still tapping. Then suddenly it slowed down and the din decreased. We were going down.

It was fearsomely quiet after the noise of the past two hours from Hampton, and we slid earthward as easily as a leaf, though we weighed all told two tons and a half and were 80 ft. of wing spread.

Then the right wing went up and the left one down and we started a spiral. Looking to my left over the wing tip I saw the new Lincoln Memorial directly beneath, and felt much as you would if your friend in a limousine should suddenly take a corner at 90 miles an hour on the hub caps of the car and smile at you to reassure you as to your safety. We were right on our hub caps and dropping a hundred feet a second. Then we leveled up easily and smoothly, then over on the right hub caps and down again. Still the earth was no nearer. Again we did it the other way, and a half dozen times more, then swept full speed, with engines roaring again, across the polo grounds, but 200 ft. up, the mob below waving like mad. A swing again to the right, another to the left, and we came down over the trees gracefully as any tiny bird, barely touched the wheels to the ground, bounced off, touched again, and slowly stopped within a few feet of the officials who were awaiting our coming.

There was no military significance to this voyage in the air, and there was no object other than demonstrating the advance in aircraft which Europe has made. It was an aerial joy ride, with the passengers to learn what might in the near future be expected in aerial travel, but we learned our lesson well.

And, as I think it over, I see multi-colored planes rising from the Detroit Aerodrome near Fort Wayne, and winging their way at 100 miles an hour across for Cleveland and Buffalo with 50 passengers each; and I see machines landing from Chicago, Buffalo and New York and a transcontinental plane goes buzzing overhead without stopping. Aerial taxis are operating from Chicago, and Flint, and Toledo, and to all towns in a 200-mile radius and over, for it is now a commercial necessity that every city should have its own landing field and hangars.

I see as well the mails, driving through the night at 150 miles an hour, the letters written at 5 in the evening before in New York being on your desk at 8 the next morning, while mail you are writing this morning will be delivered in Chicago this afternoon. This is not over vision. To those who are familiar with what is—not what is to be—this is not only possible but here as soon as the war is over, and with it will come an industry greater than the automobile industry and more far-reaching in its changes for civilization than any invention ever brought to man.

From an article in *D. A. C. News* by William B. Stout of the Aircraft Production Board.

REPORT OF NOVEMBER COUNCIL MEETING

THE November meeting of the Council was held on the 12th at the Washington office of the Society, those present being President George W. Dunham, Second Vice-President Charles M. Manly, Councilors B. B. Bachman, David Beecroft, H. L. Horning, F. E. Moskovics, John G. Utz, Treasurer Herbert Chase and General Manager Coker F. Clarkson.

A report was accepted from Councilor Beecroft as chairman of the Meetings Committee of the Society. The Chicago dinner will cost $3 per plate, while the New York dinner, to be held Jan. 10 at the Hotel Biltmore, will cost $5 per plate. F. E. Place and Leonard Kebler have been appointed members of the Meetings Committee to assist Chairman Beecroft. Arrangements are pro-

gressing satisfactorily to secure a number of interesting technical papers at both meetings. Those to be presented at the New York meeting will deal mainly with aircraft and motor trucks as used for war purposes, while the Chicago technical session will be devoted to the consideration of tractor engineering activities. A number of men prominent in public life have signified their intentions of speaking at the dinners.

Applicants to the number of 132 were elected to membership in the Society, these being assigned to grades as follows: 39 Members, 56 Associate Members, 17 Junior Members, 5 Affiliate Members, 9 Affiliate Member Representatives, and 6 Student Enrollments.

The resignations of R. O. Gill as chairman and Lester D. Gardner as a member of the Membership Committee were accepted and they were given a vote of thanks for their services to the Society. It was announced that Councilor C. E. McKinley was appointed chairman of the Committee in place of Mr. Gill. Plans are being made to prosecute the membership work vigorously, a change being contemplated in the present office organization of the Society so that one of the staff can spend practically all his time in acting as secretary to the Membership Committee.

It was voted to be the sense of the Council that an effort should be made to induce the executives as well as the engineers of the automotive industry to participate in the benefits enjoyed by Society members.

The matter of changing the Constitution so as to establish a foreign grade and a United Service grade of membership was considered, and it was decided to give further study to the possibilities of these proposed grades.

Arrangements will be made to consider the remission of dues of members going into the Government service on account of the war and also to take steps to decide just how the Society publications should be mailed to such members.

It was voted to make the following transfers in grade of membership: From Associate to Member grade, M. Reed Bass, J. S. Clapper, F. G. Diffen, M. W. Hanks, Otto H. Jobski, L. P. Jones, B. B. Mears, G. Clinton Patrick, V. I. Shobe, F. P. Steele, C. T. Stevens, Frederick P. Upton, A. V. Verville. From Junior to Associate grade, Arthur S. Mann.

A report on section matters was presented by Councilor Bachman as chairman of the Sections Committee. This report stated that good progress was being made in establishing new sections in prominent automotive engineering centers. The suggestion was made in the report that the Society should cooperate with local engineering bodies in cases where it was possible to establish a section of the Society that could affiliate with the local society. It was voted to be the sense of the Council that this cooperation should be extended, provided the financial and other relations of the S. A. E. Sections with the local bodies be approved by the Council before going into effect.

In view of the large number of members of the Society at present in Washington, the suggestion was made that a Washington Section might be of benefit to the members there and to the Government. It was decided to refer the matter to the Washington office for consideration to see whether informal monthly dinners might be held to which all members would be invited and at which Society matters of general interest could be discussed.

It was voted that the Council favors the meetings to discuss aeronautic and screw-thread standardization to be held in London in January and that the invitation to send its representatives of the Society to these meetings be accepted.

The following appointments were made to the Standards Committee:

J. F. Max Patitz, with assignment to the Tractor Division; H. E. Talbott and Noble Foss, with assignment to the Aeronautic Division. The resignations of H. D. Church, chairman of the Truck Division, and of H. L. Horning as chairman of the Tractor Division were accepted with regrets and the thanks of the Council extended to these members for their work. Dent Parrett was appointed a member of the Committee and also chairman of the Tractor Division.

The Tractor Division was requested to draw up proposed rules for a tractor contest, these to be submitted to the Council for consideration.

A plan of designating subjects completed by Aeronautic and Motorcycle Divisions as "Recommended Practice" instead of as standards was approved. This refers to the work having been done by these Divisions for Government Departments. The Council also approved the practice suggested of releasing the recommended practices to the Government Departments immediately after their approval by the Aeronautic or Motorcycle Divisions. This is a war measure taken in order to give the Government immediate information regarding standardization work in which it is interested.

It was decided to call the next meeting of the Council Dec. 10 at Washington.

SERVICE DIRECTORY OF MEMBERS

THE following list is intended to contain the names of all members connected with the Government either in the military services or in civilian capacities. The names are listed in two parts, the first showing the members who have actually entered the military services, and the second those engaged as civilians. Every effort is made to have the addresses correct, but many of the members are changing about so much that it is almost impossible to tell accurately as to just where they are located at any given time. It is therefore requested, in case of any error, that the member concerned immediately inform the New York Office of the Society, so that a proper correction can be made. Members who have actually entered the service in any capacity, and who are not listed, should also write the details to the New York Office.

MILITARY HONOR ROLL

Alden, Herbert W., major, Motor Equipment Section, Carriage Division, Ordnance O. R. C., A. E. F., France.

Ames, Butler, brigadier general, Mass. State Militia, Lowell, Mass.

Anderson, William C., lieutenant, Engineer O. R. C., Brooklyn, N. Y.

Arnold, Bion J., major, Engineer O. R. C., Washington.

Barker, C. Norman, pilot cadet, Royal Flying Corps, Camp Borden, Can.

Barton, W. E., first lieutenant, Quartermaster O. R. C., Washington.

Bibb, John T., Jr., private, U. S. School of Military Aeronautics, Signal Corps, U. S. A., Austin, Tex.

Blank, M. H., first lieutenant, Ordnance O. R. C., Washington.

Blood, Howard E., lieutenant, Engine Design Section, Equipment Division, Signal Corps, U. S. A., Washington.

Britten, Wm. B., captain, assistant to Officer in Charge of Transportation, Quartermaster O. R. C., Washington.

Browne, Arthur B., captain, Sanitary Corps, U.S.N.A., (mail) General Motors Co., Detroit.

Brown, Harold Haskell, first lieutenant, New York Artillery, Centerport, L. I.

Callan, John Lansing, lieutenant, Reserve Flying Corps, U. S. N., U. S. S. Seattle, (mail) Postmaster, New York.

Clark, Edward L., first lieutenant, Signal O. R. C., McCook Field, Dayton, Ohio.

Clark, Virginius E., lieutenant colonel, Signal Corps, U. S. A., McCook Field, Dayton, Ohio.

Coe, Edw. M., first lieutenant, Quartermaster Corps, U. S. A., Washington.

Deeds, Edward A., colonel, Equipment Division, Signal Corps, U. S. A., Washington.

De Lorenzi, Ernest A., officer, Mechanical Transport, War Department, London, Eng.

De Witt, George W., lieutenant, U. S. Naval Militia, Jacksonville, Fla.

Dickey, Herbert L., captain, Motor Equipment Section, Carriage Division, Ordnance O. R. C., Washington.

Earle, Lawrence H., first lieutenant, Ordnance O. R. C., assigned as inspector of ordnance, Holt Mfg. Co., Peoria, Ill.

Farrell, Matthew, captain, Quartermaster O. R. C., Washington.

Furlow, James W., lieutenant colonel, Quartermaster Corps, U. S. A., Washington, assigned to Office of Quartermaster General.

Fishleigh, W. T., major, Sanitary Corps, U. S. N. A., Washington, assigned as automobile engineer.

Flanigan, E. B., Officers' Reserve Training Camp, Plattsburg, N. Y.

Forrer, J. D., captain, Engineer O. R. C., Washington.

Foss, Clarence M., captain, Ordnance O. R. C., Washington.

Gaebelein, Arno W., lieutenant, Ordnance O. R. C., Washington, assigned to Carriage Division.

Gardner, Lester D., captain, 117th Aero Squadron, Signal Corps, U. S. A., Washington.

Gforer, A. H., first lieutenant, Ordnance O. R. C., Washington.

Gillis, Harry A., major, Ordnance O. R. C., Washington.

Gorrell, Edgar S., lieutenant colonel, Aviation Section, Signal Corps, U. S. A., Washington.

Gray, B. D., major, Equipment Division, Aviation Section, Signal O. R. C., Washington.

Green, Geo. A., captain, Tank Section, B. E. F., France.

Guthrie, James, major, Ordnance O. R. C., Washington, assigned to Field Artillery Section, Carriage Division.

Hegeman, Harry A., major, Quartermaster Corps, U. S. A., Washington, assigned to Office of Officer in Charge of Transportation.

Hall, Elbert J., major, Engine Design Section, Engineering Division, Signal Corps, U. S. A., Washington.

Harms, Henry W., captain, Av. Sec., Signal Corps, U. S. A., Washington.

Hartman, A. A., private, U. S. National Army, Camp Devons, Ayer, Mass.

Horner, Leonard S., major, Equipment Division, Signal Corps, U. S. A., Washington.

Hubbell, Lindley D., major, Ordnance O. R. C., Springfield, Mass., assigned as Officer in Charge, Hill Shops, Springfield, Armory.

Jennings, J. J., sergeant, Quartermaster Enlisted Reserve, A. E. F., France.

Joy, Henry B., captain, Aviation Section, Signal O. R. C., Washington.

Kline, Harmon J., Officers' Reserve Training Camp, Fortress Monroe, Va.

Lanza, Manfred, major, Quartermaster Corps, U. S. A., headquarters 78th Division, Camp Dix, N. J.

Larsen, Lester Reginald, second lieutenant, Engineer O. R. C., Washington.

Lay, Arthur J. captain, Aviation Section, Signal O. R. C., Washington.

LeFevre, Wm. G., lieutenant, Ordnance O. R. C., Washington.

Lewis, Charles B., captain, Ordnance O. R. C., Camp Lewis, American Lake, Wash.

Lewis, Harry R., Jr., first lieutenant, Ordnance O. R. C., Springfield Armory, Springfield, Mass.

Lipsner, B. B., captain, Air Division, Aviation Section, Signal O. R. C., Washington.

May, O. J., captain, Aviation Section, Signal O. R. C., Camp Custer, Battle Creek, Mich.

McIntyre, H. C., captain, Ordnance O. R. C., Washington.

Mackie, Mitchell, adjutant, Quartermaster Corps, U. S. A., A. E. F., France, assigned to Motor Truck Transport Section.

Marmon, Howard, captain, Airplane Engineering Department, Aviation Section, Signal O. R. C., McCook Field, Dayton, Ohio.

Martin, Kingsley G., captain, Quartermaster O. R. C., Washington, assigned to Southern Department.

Middleton, Ray T., sergeant, Quartermaster Enlisted Reserve, A. E. F., France.

Morgan, M. B., captain, Ordnance O. R. C., Washington.

Myers, J. L., first lieutenant, Ordnance O. R. C., Washington.

Ommundson, H. P., Flying Corps, U. S. N., Aeronautic Station, Pensacola, Fla.

Page, Victor W., first lieutenant, Aviation Section, Signal O. R. C., Mineola, N. Y.

Parker, Richard E., captain, Quartermaster O. R. C., Washington, assigned to Southern Department.

Pearmain, W. J., captain, Ordnance O. R. C., Washington.

Peifer, Carl B., lieutenant, Specification Section, Signal Corps, U. S. A., Washington.

Potter, Austin E., lieutenant, New York Naval Militia, Brooklyn, N. Y.

Powell, W. B., officer in charge of transportation, Imperial Ministry of Munitions, (mail) Box 94, Quebec, Can.

Pullen, Daniel D., captain, 7th Regiment, Engineer Corps, U. S. A., Fort Leavenworth, Kan.

Ranney, A. Elliot, major, Air Division, Signal Corps, U. S. A., Washington.

Rose, Charles B., captain, Equipment Division, Signal Corps, U. S. A., Washington.

Rosenthal, Wm. C., private, U. S. N. A., 507 Nineteen Hundred Euclid Bldg., Cleveland.

Schoepf, T. N., captain, Engineer O. R. C., Washington.

Selfridge, S. W., first lieutenant, Ordnance O. R. C., Washington.

Slade, Arthur J., captain, Aviation Section, Signal O. R. C., Washington.

Smith, Mark A., first lieutenant, Marine Corps, U. S. N., Washington.

Strahlman, Otto E., first lieutenant, Aviation Section, Signal O. R. C., (mail) McCook Field, Dayton, Ohio.

Thomson, Clarke, lieutenant, Signal O. R. C., Washington.

Thompson, H. E., first lieutenant, Motor Equipment Section, Carriage Division, Ordnance O. R. C., Washington.

Tolman, Edgar Bronson, Jr., first lieutenant, 311th Engineers, U. S. A., Camp Grant, Rockford, Ill.

Twachtman, Quentin, first lieutenant, Engine Design Section, Signal O. R. C., Washington.

Vincent, Jesse G., major, Aviation Section, Signal Corps, U. S. A., Miami Hotel, Dayton, Ohio.

Waldon, Sidney D., colonel, Equipment Division, Signal Corps, U. S. A., Washington.

Wall, William Guy, major, Ordnance O. R. C., Washington, asigned to motorization work.

Walter, Maurice, first lieutenant, Ordnance O. R. C., Washington.

Walton, Frank, acting sergeant, Quartermaster Corps, U. S. A., assigned to Quartermaster Repair Unit, Camp Meigs.

Wetherill, S. P., Jr., major, Quartermaster O. R. C., Washington.

Whittenberger, Owen M., first lieutenant, Ordnance O. R. C., Washington, assigned to Office of Chief of Ordnance.

Wilson, T. S., major, First Indiana Field Artillery, Lafayette, Ind.

Wood, Harold F., lieutenant, Specification Section, Equipment Division, Signal O. R. C., Washington.

Recent Additions

Eells, Paul W., lieutenant, 330th Field Artillery, O. R. C., Camp Custer, Battle Creek, Mich.

Fox, Rudolph H., first lieutenant, Ordnance O. R. C., Washington.

Lavery, Geo. L., Jr., first lieutenant, Ordnance O. R. C., Washington.

Marshal, W. C., captain, Ordnance O. R. C., Washington.

Moffat, Alex. W., ensign, commanding U. S. S. "Tamarack" (S. P. 561), Naval Defense Reserve, Postmaster, Foreign Station, New York.

Nahikian, S. M., 4th Battery, Second O. T. R., Ft. Sheridan, Ill.

Paine, C. L., captain, Ordnance O. R. C., 318 North Illinois Avenue, Indianapolis, assigned to work on tanks.

Pfeiffer, Ben. S., first lieutenant, Ordnance O. R. C., Rock Island Arsenal, Rock Island, Ill., assigned to Motor Section.

Schoenfuss, F. H., captain, Ordnance O. R. C., Washington.

Sprague, G. A., Co. D., 310th Engineers, Camp Custer, Battle Creek, Mich.

Swinton, D. R., first lieutenant, Quartermaster Corps, U. S. A., assigned to Office of Quartermaster General.

Turner, Harry C., captain, 1006 California Bldg., Los Angeles, Cal.

Vail, E. L., lieutenant, Signal Corps, U. S. A., Washington.

Civilian Honor Roll

Adams, Porter H., Office of the Section Commander, First Naval District, Rockford, Me.

Bare, Erwin L., automobile body designer, Office of Quartermaster General, Washington.

Barnhardt, Geo. E., instructor, Signal Corps Aviation School, San Diego, Cal.

Bourquin, J. F., supervisor of chassis assembly, Military Truck Production Section, Office of Quartermaster General, Washington.

Caldwell, Frank W., aeronautical mechanical engineer, Aviation Section, Signal Corps, Washington, (mail) 1449 Massachusetts Avenue, N. W.

Chauveau, Roger, aeronautical mechanical engineer, Aviation Section, Signal Corps, Washington.

Coffin, Howard E., chairman, Aircraft Production Board, Washington.

Costello, John V., aeronautical engineer, Aviation Section, Signal Corps, Washington.

DeKlyn, John H., technical assistant, National Advisory Committee on Aeronautics, Washington.

Diffin, F. G., chairman, International Aircraft Standards Board, Washington.

Ericson, Friehof G., representative of Canada, International Aircraft Standards Board, Washington.

Fowler, Harlan D., aeronautical engineer, Aviation Section, Signal Corps, Mineola, N. Y.

Gill, R. O., inspector of airplanes, Equipment Division, Signal Corps, (mail), Dayton-Wright Airplane Co., Dayton, Ohio.

Girl, Christian, director, Military Truck Production Section, Office of Quartermaster General, Washington.

Hallett, Geo. E. A., aeronautical mechanical engineer, Signal Corps, Aviation School, San Diego, Cal.

Hobbs, J. W., automobile expert, Ordnance Department, Rock Island Arsenal, Rock Island, Ill.

Horine, M. C., inspector, Aircraft Engineering Division, Signal Corps, Washington.

Hoyt, F. R., Aviation Section, Signal Corps, Washington.

King, Charles B., aeronautical mechanical engineer, Aviation Section, Signal Corps, Washington.

Lane, Abbott A., inspector, Aviation Section, Signal Corps (mail), Room 52, 870 Woodward Avenue, Detroit.

McMaster, Marcenus D., aeronautical engineer, Equipment Division, Signal Corps, Washington.

Morgan, G. W., supervisor of plant survey, Military Truck Production Section, Office of Quartermaster General, Washington.

Neumann, John W., Planning Section, Machine Division, U. S. Navy Yard, Philadelphia.

Norris, G. L., Inspection Section, Equipment Division, Signal Corps, Washington.

O'Malley, John M., instructor in motor engineering, Aviation School, Signal Corps, Washington.

Parris, Jr., Edward L., senior inspector, Aviation Section, Signal Corps, (mail) Ericsson Mfg. Co., Buffalo.

Rice, Harvey M., inspector, Aviation Section, Signal Corps, (mail) Curtiss Aeroplane Co., Buffalo.

Rippingille, E. V., Aviation Section, Signal Corps, Washington.

Rogers, John M., aeronautical engineer, Bureau of Construction & Repair, Navy Department, Washington.

Salisbury, Edward V., chief of motor transportation.

American International Corp., Government Shipbuilding Yard, Hog Island, Philadelphia.

Schupp, Arthur A., aeronautical mechanical engineer, Aviation Section, Signal Corps, Washington.

Serrell, Ernest, aeronautical mechanical engineer, Aviation Section, Signal Corps, Washington.

Stout, William B., member International Aircraft Standards Board, Washington.

Tone, Fred I., inspector, Aviation Section, Signal Corps, Washington.

Tracy, Percy Wheeler, supervisor of parts plants, Military Truck Production Section, Office of Quartermaster General, Washington.

Utz, John G., supervisor of inspection, Office of Military Truck Production Section, Office of Quartermaster General, Washington.

Van Loon, Henry M., 310th Engineers, Camp Custer, Battle Creek, Mich.

Wade, Gustav, inspector, Aviation Section, Signal Corps, Washington.

Walter, John M., mechanical draftsman, Bureau of Ordnance, Navy Department, Washington.

Waterhouse, W. J. aeronautical engineer, Aviation Section, Signal Corps, (mail) Dayton-Wright Airplane Co., Dayton, Ohio.

Recent Additions

Chapman, Robert H., U. S. N., Spartanburg, S. C., assigned to Aeronautical Division.

Edgerton, A. H., aeronautical mechanical engineer, Inspection Section, Signal Corps, U. S. A., assigned to Equipment Division.

Elliott, E. M., U. S. Public Service Reserve, Department of Labor, 1712 I Street, Washington.

Gorman, E. J. B., U. S. Naval Reserve Flying Corps, Dayton, Ohio, assigned to inspection of airplane engines, Dayton-Wright Aeroplane Co.

Gunn, E. G., production engineer, Quartermaster Corps, U. S. A., Washington, assigned to Motor Transportation Division.

Holden, F. M., airplane engineering department, Signal Corps, U. S. A., Washington.

Kishline, Floyd F., laboratory assistant, Quartermaster Corps, Washington.

McCain, Geo. L., Signal Corps, U. S. A., Dayton, Ohio, assigned to airplane engineering department, Engine Design Section.

Mennen, F. E., Quartermaster Corps, U. S. A., Washington, assigned to Transportation Division.

Otis, J. Hawley, Ordnance Department, U. S. A., Camp Dodge, Des Moines, Iowa.

Parish, W. F., Signal Corps, U. S. A., Washington, assigned to Specification Section, Equipment Division.

Parker, Victor C., Signal Corps, U. S. A., Washington, assigned to Equipment Division.

Perrin, J. G., assistant, Signal Corps, U. S. A., Washington, assigned to Office of Chief Signal Officer.

Proctor, C. D., Ordnance Department, U. S. A., Rock Island Arsenal, Rock Island, Ill. Assigned to Motor Section, Carriage Division.

Sloane, Jno. E., Signal Corps, U. S. A., Washington, assigned to Equipment Division.

Smith, G. W., Jr., aeronautical mechanical engineer in charge of experimental division, Engineering Department, Naval Aircraft Factory, U. S. Navy Yard, Philadelphia.

Stanton, D. T., military instructor, U. S. Army School of Military Aeronautics, Cornell University, Ithaca, N. Y.

Waldron, Russell E., Signal Corps, U. S. A., Detroit, assigned to Equipment Division.

Whinne, Wilbur H., inspector, Quartermaster Corps. U. S. A., Detroit.

PERSONAL NOTES OF THE MEMBERS

Joseph A. Anglada, formerly vice-president, United States Wheel Co., Chicago, is now vice-president, general manager, Commercial Car Unit Co., Philadelphia.

F. R. Bacon, formerly president, Cutler-Hammer Mfg. Co., Milwaukee, Wis., is now located at 195 Church Street, New Haven, Conn.

R. C. Barron, formerly assistant chief draftsman, Curtiss Aeroplane & Motor Corp., Buffalo, is now chief draftsman, experimental motor division of the same company.

Howard C. Benedict, formerly works manager, Aeromarine Plane & Motor Co., Keyport, N. J., is now works manager, The Glenn L. Martin Co., Cleveland.

John T. Boone, formerly chief engineer, Disco Electric Starter Corp., Detroit, is now consulting and designing engineer, Allen & Boone, 58 Garfield Building, Detroit.

James S. Booth has severed his connections as second vice-president, Scripps-Booth Corp., Detroit.

Otto Bruenauer, former engineering manager, U. S. Ball Bearing Mfg. Co., is now director of sales and engineering of the same company.

Charles A. Chevraux, formerly secretary, Cleveland-Canton Spring Co., Canton, Ohio, is now production manager, Jenkins Vulcan Spring Co., Richmond, Ind.

Carr L. Clark, formerly assistant chief engineer, Driggs-Seabury Ordnance Co., is now engineer with the Savage Arms Corp., Sharon, Pa.

Emerson L. Clark, formerly consulting engineer, Lakewood, Ohio, is with the Grant Motor Car Corp., Cleveland.

William L. Colt, formerly president, Colt-Stratton Co., New York, is now branch manager, Willys-Overland, Inc., New York.

E. A. Corbin, Jr., formerly engineer, Rush Motor Truck Co., is now in engineering department, Commercial Car Unit Co., Philadelphia.

Charles Sharp Crawford, formerly associate engineer, is now chief engineer and assistant general manager, Premier Motor Corp., Indianapolis.

A. B. Cumner, formerly service manager, Autocar Co., New York, is now in charge of the Autocar Sales & Service Co., Washington.

R. E. Davis, formerly assistant superintendent, tractor department, Moline Plow Co., Moline, Ill., is now designer, Advance Rumely Co., Laporte, Ind.

H. L. Davisson, formerly partner, Jones, Humphrey & Davisson, New York, is now manager, industrial truck and tractor department, Edison Storage Battery Co., Orange, N. J.

E. H. Delling, formerly superintendent of inspection, is now research engineer, Saxon Motor Car Corp., Detroit.

G. F. Discher, formerly president, Garage Equipment Mfg. Co., Milwaukee, Wis., is now president, Gemco Mfg. Co., Milwaukee, Wis.

Stephen O. D'Orlow, chief engineer, Oak Mfg. Co., is doing special engineering work for the Republic Motor Truck Co., Alma, Mich.

W. E. Duersten, formerly western territorial manager, Super Spark Co., St. Louis, is now production planning

superintendent, Firestone Tire & Rubber Co., Akron, Ohio.

A. O. Dunk, formerly with Detroiter Motor Car Co., Detroit, is now with the Puritan Machine Co., 415 Lafayette Boulevard, Detroit.

C. H. Dunlap, formerly at Detroit, is now with E. A. Nelson, Bellevue and Kercheval avenues, Detroit.

A. C. Duringer has severed his connections as assistant chief engineer with the Militaire Motor Vehicle Co., Buffalo.

Francis E. Edwards, formerly consul, The Lincoln Highway Association, Inc., Chicago, is at Crystal Lake, Ill.

Phillips B. Ferry, formerly assistant designing engineer, Wright Martin Aircraft Corp., New York, is now located at 419 Guardian Building, Cleveland.

G. M. Flint, formerly with Willys-Overland Co., Toledo, Ohio, is now with Overland Pacific, Inc., Portland, Ore.

Albert G. Geistert, formerly engineer, Scripps-Booth Corp., Detroit, is now chief checker, Chevrolet Motor Co., New York.

Raymond D. Guy, formerly assistant to acting chief engineer, Wright-Martin Aircraft Corp., New York, is now engineer, Autocar Sales Co., New York.

J. D. Hammond, formerly chief engineer, Emerson Motors Co., Kingston, N. Y., is now chief engineer, Campbell Motor Car Co., Kingston, N. Y.

S. E. Hanselman, formerly foreman machine department, Bernhard & Turner Auto Co., Des Moines, Iowa, is now production manager, Youngstrom Auto Co.

H. A. Hicks, formerly student in mechanical engineering, University of Michigan, Ann Arbor, Mich., is now instructor in mechanical and automobile engineering.

William H. Hill, formerly treasurer, is now vice-president and assistant general manager, The Crosby Co., Buffalo.

Herman Hollerith, Jr., formerly student at Worcester Polytechnic Institute, Worcester, Mass., is now in the research department of the White Motor Co., Cleveland.

R. B. Jackson, formerly treasurer and general manager, is now treasurer and vice-president, Hudson Motor Car Co., and also vice-president, Essex Motors, Detroit.

Lloyd P. Jones, formerly sales manager, is now vice-president and general manager, Federal Brass Works, Detroit.

R. B. Jones, formerly chief draftsman, Curtiss Aeroplane Co., Buffalo, is now aeronautical production engineer, Curtiss Aeroplane & Motor Corp., Buffalo.

Charles G. Keller, formerly chief engineer, assistant factory manager, Nagle ReBlade Knife Co., Poughkeepsie, N. Y., is now engineer, Robeson Cutlery Co., Perry, N. Y.

Laurence A. King, formerly student, Armour Institute of Technology, is now ship fitter at Fore River Shipbuilding Corp., Quincy, Mass.

E. P. Kirchhofer, formerly production manager, Elkhart Carriage and Motor Car Co., Elkhart, Ind., is now production and factory manager, Tulsa Automobile Corp., Tulsa, Okla.

Alvin F. Knobloch, formerly general manager, Cole Motor Car Co., Indianapolis, is now works manager, Cleveland Tractor Co., Cleveland.

Edwin H. Kottnauer, formerly metallurgical engineer, Four Wheel Drive Auto Co., Clintonville, is now metallurgical engineer, Pierce-Arrow Motor Car Co., Buffalo.

James Levy, formerly president, treasurer, Chalmers Motor Co. of Illinois, Chicago, is now president of James Levy Motors Co., Chicago.

W. V. Logan has severed his connections as eastern district manager, McGraw Tire & Rubber Co., E. Palestine, Ohio.

Alexander B. McKechnie, formerly mechanical engineer, is now sales engineer, The Merrill Process Co., Boston.

V. J. Mayo, formerly manager, Mayo Radiator Co., New Haven, Conn., is now manager, president and treasurer, Mayo Engineering Co., 103 Park Avenue, New York.

Edgar D. Moore, formerly efficiency engineer, Remington Arms & Ammunition Co., Ilion, N. Y., is now production manager, Lincoln Electric Co., Cleveland.

E. C. Morse has severed his connections as vice-president and general manager, Chalmers Motor Co., Detroit.

Joseph Lafayette Moss, Jr., formerly chief engineer, Consolidated Motors Corp., New York, is now mechanical engineer, Elco Works, Electric Boat Corp., Avenue A, Bayonne, N. J.

Louis Petersen, formerly chief draftsman, Herschell-Spillman Co., North Tonawanda, N. Y., is now tool designer with The Remington Arms Co., Bridgeport, Conn.

Alfred J. Poole, formerly branch manager, Bosch Magneto Co., New York, is now with the Wire Wheel Corp. of America, Buffalo.

J. Malcolm Randall, formerly mechanic, is now road engineer, The Buda Co., Harvey, Ill.

Ned S. Reed, formerly designer, Garfield Motor Truck Co., Lima, Ohio, is now with The Bowling Green Motor Truck Co., Bowling Green, Ohio.

Louis Renault has severed his connection as chief draftsman of the Gas-Electric Motorbus Corp., Chicago.

Henry Schaeffer, formerly chief draftsman, Woods Motor Vehicle Co., Chicago, is now assistant chief engineer, Oak Mfg. Co., Alma, Mich.

B. Russell Shaw, formerly chief engineer and designer, William P. Bonbright & Co., Detroit, is now consulting engineer, The Lawson Aircraft Corp., Green Bay, Wis.

O. H. Skinner, formerly general superintendent, is now general superintendent and chief engineer, The Prest-O-Lite Co., Inc., Indianapolis.

Edwin M. Smith, formerly chief engineer, Bessemer Motor Truck Co., Grove City, Pa., is now with the Holt Mfg. Co., Peoria, Ill.

Lyle K. Snell, formerly chassis engineer, Cadillac Motor Car Co., is now engineer, Willys-Overland Co., Toledo, Ohio.

H. J. Stoops, formerly with Motor Products Corp., Detroit, is now manager, Motor Products Corp., Ltd., Walkerville, Ont., Detroit.

E. E. Sweet, formerly consulting engineer, Cadillac Motor Car Co., Detroit, is now at 195 Chandler Avenue, Detroit.

Harris R. Till, formerly foreman inspector, motor department, is now service manager, The W. K. Lovering Co., Salt Lake City, Utah.

A. D. Trempe, formerly service and sales manager, Perlman Rim Corp., New York, is now service and sales manager, the Jackson Rim Co., Jackson, Mich.

D. P. Turnbull has severed his connections as treasurer, Chalmers Motor Co., Detroit.

W. H. VanDervoort, president and general manager, Root & VanDervoort Engineering Co.; The Moline Automobile Co., E. Moline, Ill., is now president, general manager, R. & V. Wagner Ordnance Co., E. Moline, Ill.

H. A. Wagner, formerly manager, Mercer Motor Sales Co., Toledo, Ohio, is now connected with the Beam Fletcher Corp., Philadelphia.

H. G. Weaver, formerly assistant general manager, Sun

Motor Car Co., Elkhart, Ind., is now located at Eatonton, Ga.

G. W. Wesley has severed his connection as vice-president in charge of engineering and production, General Vehicle Co., Long Island City.

D. McCall White, formerly chief engineer, is now vice-president and assistant general manager, Cadillac Motor Car Co., Detroit.

Stanley Whitworth, formerly production manager, Mutual Motors Co., Jackson, Mich., is now with the Nordyke & Marmon Co., Indianapolis.

J. D. Wiggins, formerly works manager, Findeisen & Kropf Mfg. Co., Chicago, is now manager, American Ball Bearing Co., The Standard Parts Co., Cleveland.

Chas. F. Willard, formerly president and engineer, Aeromarine Engineering & Sales Co., New York, is now consulting engineer, Aeromarine Plane and Motor Co., New York.

M. W. H. Wilson, formerly assistant superintendent, Cadillac Motor Car Co., Detroit, is now general superintendent, Lincoln Motor Co., Detroit.

Applications *for* Membership

A list of current applications for membership is given below. The members are urged to send any pertinent information with regard to those whose names are given which the Council should have for consideration prior to their election. It is requested that such communications from members should be sent promptly.

AGINS, HERMAN J., draftsman, Quartermaster Engineering Division, War Department, *Washington.*

ALDRIN, EDWIN E., student, Massachusetts Institute of Technology, *Cambridge, Mass.*

ALLISON, LAWRENCE M., chief engineer, Lawson Aircraft Corp., *Green Bay, Wis.*

AYERS, BURLEY B., advertising manager, American Steel and Wire Co., *Chicago.*

BARROWS, FREDERICK IRVING, secretary-treasurer, Lexington Motor Co., *Connersville, Ind.*

BURKNESS, NEIL B., chief engineer, Kleiber & Co., *San Francisco.*

BRINKMEYER, HARRY F., vice-president, Pioneer Brass Works, *Indianapolis.*

CARROLL, JOHN G., general engineer, Westinghouse Elec. & Mfg. Co., *East Pittsburgh, Pa.*

CHRISTENSEN, N. A., president, The Christensen Engineering Co., *Milwaukee, Wis.*

CITROEN, ANDRE, owner, Andre Citroen Factory, 143 Quai de Javel, *Paris, France.*

DAWSON, FRANK, engineer, factory manager, purchasing agent, Master Trucks, Inc., *Indianapolis.*

DAY, CLARENCE M., president, Perlman Rim Corp., Jackson Rim Co., *Jackson, Mich.*

DE LA GARDE, LOUIS AUGUSTE CHARLES, lieut., engineer workshops officer, Motor Transport Army Service Corps., Heavy Artillery, *London, England.*

EARL, CLARENCE A., vice-president, Willys Overland Co., *Toledo, Ohio.*

EVANS, SANFORD, assistant engineer, Aeromarine Plane & Motor Co., *Keyport, N. J.*

FARWELL, HAROLD G., chief engineer, The Raybestos Co., *Bridgeport, Conn.*

FITNESS, R. J., assistant chief engineer, Pan Motor Co., *St. Cloud, Minn.*

GEMMER, GEORGE ANDREW, chief engineer, Day-Elder Motors Corp., *Newark, N. J.*

GOHLMAN, HARRY DAVID, engineer, salesman, The Texas Co., *Houston, Tex.*

GORMORY, ALBERT B., production engineer, Hendee Mfg. Co., *Springfield, Mass.*

GREEN, ROBERT H., assistant engineer, Minneapolis Steel & Machinery Co., *Minneapolis.*

GRIFFIN, JAMES C., president, The Griffin Mfg. Co., *Erie, Pa.*

GURNEY, EDWIN GOODNOW, designer, Holt Mfg. Co., *Stockton, Cal.*

HARRIS, FREDERICK, assistant sales agent, Hoyt Metal Co., *St. Louis, Mo.*

HEDSTROM, C. OSCAR, mechanical engineer, Hendee Mfg. Co., *Springfield, Mass.*

HENES, HENRY W., engineering department, Stromberg Motor Devices Co., *Chicago.*

HOBBS, CARL E., proprietor, Hobbs Electric Repair Shop, *Springfield, Ill.*

HOFFMAN, T., general manager, director, 39 Rue Franklin, *Ivry-Port Seine, France.*

HOLZAEPFEL, NORMAN RUDOLPH, draftsman, Dauch Mfg. Co., *Sandusky, Ohio.*

HOPEWELL, CHARLES F., proprietor, Hopewell Brothers, *Watertown, Mass.*

HORTON, ALLEN A., designer, Henry Ford & Son, Inc., *Dearborn, Mich.*

HULL, MATTHEW ROBINSON, general superintendent, Rex Mfg. Co., *Connersville, Ind.*

HULL, MATTHIAS LAIR, production manager, Rex Mfg. Co., *Connersville, Ind.*

KANE, EDMUND J., mechanical engineer, 123 N. Waller Avenue, *Chicago.*

KANE, FOREST H., chief draftsman, Oakland Motor Car Co., *Pontiac, Mich.*

KAUFMAN, CHARLES L., purchasing agent, supervising engineer, Export Development Association of America, *New York.*

KINGSBURY, JESSE A., metallurgist, The Studebaker Corp. of America, *South Bend, Ind.*

KRANICH, FRANK N. G., agricultural engineer, Hyatt Roller Bearing Co., *Chicago.*

KUEBLER, A. W., superintendent, Stromberg Motor Devices Co., *Chicago.*

LEE, HARRY F., chief engineer, Ditwiler Mfg. Co., *Galion, Ohio.*

LENTZ, SAMUEL F., lubrication engineer, The Texas Co., *Chicago.*

LONN, E. JULIUS, president, Great Western Mfg. Co., *LaPorte, Ind.*

MORTON, R. B., chief engineer, Lennox Motor Car Co., *Hyde Park, Mass.*

MELCHER, L. W., works manager, chief engineer, La Crosse Tractor Co., *La Crosse, Wis.*

MILLS, STANLEY W., chief engineer, Highway Tractor Co., *Indianapolis.*

MOODY, CHESTER SHERMAN, assistant metallurgist, Minneapolis Steel and Machinery Co., *Minneapolis.*

PETERSON, F. SOMERS, manufacturers' agent, F. Somers Peterson Co., *San Francisco.*

PRESTON, E. R., sales manager, aeronautic supplies department, The Goodyear Tire & Rubber Co., *Akron, Ohio.*

REILLY, JOHN F., chief draftsman, Curtiss Aeroplane & Motor Co., *Buffalo.*

ROUNDS, EDWARD WADSWORTH, instructor in military aeronautics, Massachusetts Institute of Technology, *Boston.*

RUDOLPH, WALTER J., chief engineer, Imperial Brass Mfg. Co., *Chicago.*

RUZICKA, JOHN W., proprietor, Motor Electric Equipment Co., *Chicago.*

SCHALLER, HERMAN, designing engineer, Aultman-Taylor Machinery Co., *Mansfield, Ohio.*

SHAW, EDWART T., president, chief engineer, Berkshire Magneto Co., *Pittsfield, Mass.*

SHEEDERS, RUSSELL H., retail branch manager, Willard Storage Battery Co., *Indianapolis.*

STEINBACK, W. E., treasurer, vice-president, Eisemann Magneto Co., *Brooklyn, N. Y.*

SUTHERLAND, EDWIN M., district representative, Willard Storage Battery Co., *Moline, Ill.*

TAYLOR, FRED., designer, The Goodyear Tire & Rubber Co., *Akron, Ohio.*

THOMPSON, HAROLD T., factory superintendent, Abbott Corp., *Cleveland.*

TURKENKOPH, S. C., tractor sales and service manager, Moline Plow Co., *Moline, Ill.*

VOHRER, WILLARD R., draftsman, Quartermaster Corps, U. S. A., *Washington.*

WALTERS, CARL A., designer, Smith Motor Truck Corp., *Chicago.*

WARE, JOHN PUTNAM, factory representative, Clark Equipment Co., *Buchanan, Mich.*

WARREN, H. O., vice-president, Kleiber & Co., Inc., *San Francisco.*

WELLS, L. J., draftsman, automobile department, Rock Island Arsenal, *Davenport, Iowa.*

WHEELER, DOUGLAS F., vice-president, The Wheeler-Schebler Carburetor Co., *Indianapolis.*

WHITING, STANLEY, layout draftsman, Northway Motor & Mfg. Co., *Detroit.*

WRIGHT, EVAN HADLEY, mechanical engineer, Glenn L. Martin Airplane Co., *Los Angeles, Cal.*

YOSHZAKI, RYOZO, sales manager, Yanase & Co., *Kojimachi-Ku, Tokyo, Japan.*

Applicants *Qualified*

The following list of applicants have qualified for admission to the Society between October 17 and November 13. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (Aff. Rep.) Affiliate Representative; (S. E.) Student Enrollment.

ALVIN, FORREST J. (A) general manager, United States Motor Truck Co., *Cincinnati, Ohio.*

BERGMANN, HENRY E. (A) chief draftsman, Sterling Motor Truck Co., *Milwaukee, Wis.*

BIBB, JOHN T. JR. (J) private, Aviation Section, U. S. School of Military Aeronautics, *Austin, Tex.*, (mail) 2131 N. Prospect St., *Tacoma, Wash.*

BROOKS, W. C. (A) chemical engineer, assistant superintendent, Factory S., National Carbon Co. Inc., *Cleveland,* (mail) 1448 Highland Ave., *Lakewood, Ohio.*

BROWN, WALTER (Aff. Rep.) vice-president, general manager, The Webster Electric Co., *Racine, Wis.*

CADLE, JOHN A. (A) salesman, Willard Storage Battery Co., *Cleveland.*

CAMPBELL, ARCHIBALD FRANCIS (S. E.) engineering student, University of Michigan, *Ann Arbor, Mich.*, (mail) 314 N. Ingalls St.

CARLAW, R. H. (A) mechanical engineer, partner, David Carlaw & Sons, 11 Finnieston St., *Glasgow, Scotland,* (mail) "Flodden," 27 Cornwall Ave., Jordanhill.

CASSIDY, EDW. A. (A) president, Edward A. Cassidy Co. Inc., 280 Madison Ave., *New York.*

CHAPMAN, ROBERT H. (J) aeronautical division, U.S.N., *Washington, D. C.*, (mail) 172 E. Main St., *Spartanburg, S. C.*

CHRISTIANSEN, E. O. (Aff. Rep.) treasurer, Standard Woven Fabric Co., *Walpole, Mass.*

CRAWFORD, ROBERT (A) president, general manager, Sun Motor Car Co., *Elkhart, Ind.*

CUSHMAN MOTOR WORKS, THE (Aff. Mem.) *Lincoln, Neb.* Representative: Louis M. Ward, secretary.

DALEY, T. J. (Aff. Rep.) secretary, Standard Woven Fabric Co., *Walpole, Mass.*

DEKLYN, JOHN H. (J) technical assistant, National Advisory Committee for Aeronautics, 518 Munsey Bldg., *Washington.*

DODGE, HARRY DANIEL (Aff. Rep.) sales engineer, The Webster Electric Co., *Racine, Wis.*

EIGHMEY, DAVID T. (A) layout draftsman, F-I-A-T, *Poughkeepsie, N. Y.*, (mail) 16 Barclay St.

EVERETT, R. (Aff. Rep.) sales manager, Standard Woven Fabric Co., *Walpole, Mass.*

FISCHER, O. H., (Aff. Rep.) president, manager, The Union Gas Engine Co., *Oakland, Cal.*

GEY, WILLIAM H. (A) shop foreman, F. B. Stearns Co., 415 W. 55th St., *New York.*

GIFFORD, FRANKLIN (J) draftsman, Bijur Motor Lighting Co., *Hoboken, N. J.*, (mail) 529 Van Vorst Place, *Weehawken, N. J.*

GRAHAM, THORNTON GILLMOR, (A) production manager, Falls Rubber Co., *Cuyahoga Falls, Ohio.*

HANSEN, HERBERT A. (J) engineer, draftsman, C. L. Best Gas Traction Co., *San Leandro, Cal.*, (mail) 217 E. 12th St., *Oakland, Cal.*

HAZELETT, CLARENCE W. (J) charge of engineering department, Factory S., National Carbon Co., Inc., *Cleveland.*

HEINRICH, ALBERT S. (M) president, chief engineer, A. S. Heinrich Corp., 141 Broadway, *New York,* (mail) Langley Field, *Hampton, Va.*

KLECKNER, ARTHUR C. (Aff. Rep.) chief engineer, The Webster Electric Co., *Racine, Wis.*

HOHENTHAL, E. H. (A) sales and advertising manager, Simms Magneto Co., *E. Orange, N. J.*

HOUSE, B. E. (J) designer, Pan Motor Co., *St. Cloud, Minn.*

KRATSCH, CHARLES (M) treasurer, Sumter Electrical Co., 1466 Michigan Ave., *Chicago, Ill.*

KUIVINEN, JOHN VICTOR (S. E.) inspector, Sanitary Corps, Surgeon General's Office, U. S. A., *Washington,* (mail) 7 H St., N. W.

LOEB, S. ARTHUR (Aff. Rep.) secretary-treasurer, The Webster Electric Co., *Racine, Wis.*

MARTIN, GEO. E. (M) truck engineer, Velie Motors Corp., *Moline, Ill.*, (mail) 1807 18th Ave.

MILLER, C. S. (J) engineer, Prest-O-Lite Co., Inc., 914 C. P. R. Bldg., *Toronto, Can.*

NIXON, HENRY S. (A) superintendent, The Park Drop Forge Co., *Cleveland,* (mail) Suite 33, 1886 E. 97th St.

NORRIS, CHARLES D. (A) engineer, designer, Burlington Motor Truck Co., 160 W. Jackson Blvd., *Chicago.*

O'BRIEN, THOMAS T. (A) salesman, Willys-Overland Co., *Toledo, Ohio,* (mail) 88 Saratoga Ave., *Yonkers, N. Y.*

PATTERSON, ROBERT P. (J) assistant, engineering inspection department, Curtiss Aeroplane & Motor Corp., *Buffalo,* (mail) 277 Linwood Ave.

PERRY, WARD S. (A) general manager, Vesta Accumulator Co., 2100 Indiana Ave., *Chicago.*

PETERSON, FRANK LEROY (A) service manager in charge of instruction work, Ordnance Motor Section Instruction School, Holt Mfg. Co., *Peoria, Ill.*, (mail) 215 Barker Ave.

QUINCY, EDMUND (A) vice-president, Miller Transmission Co., 90 West St., *New York.*

RAILSBACK, L. M. (A) assistant to president, The Pittsburgh Model Engine Co., *Pittsburgh, Pa.*

READ, GEORGE ELLIOTT (A) general manager, T. Elliott Rourke & Co., Casilla-32d, *Santiago, Chile.*

ROSS, JAMES (M) chief engineer, Gile Tractor & Engine Co., 109 N. Ferry St., *Ludington, Mich.*

SCHAAF, R. A., (M) engineer, spring department, Sheldon Axle & Spring Co., *Wilkes-Barre, Pa.*, (mail) 361 N. Washington St.

SCHACHT, G. A. (M) president, The G. A. Schacht Motor Truck Co., Gest & Evans Sta., *Cincinnati.*

SHUMARD, E. C. (M) chief engineer, The United States Motor Truck Co., *Cincinnati, Ohio,* (mail) Mound St., *Milford, Ohio.*

SKINNER, ORAMEL H. (M) general superintendent, The Prest-O-Lite Co., Inc., *Indianapolis.*

SOULIS, H. A. (A) production equipment engineer, Maxim Munitions Corp., *Derby, Conn.*, (mail) 251 W. 129th St., *New York.*

STALEY, J. H. (A) general manager, Continental Auto Parts Co., *Knightstown, Ind.*

STANDARD WOVEN FABRIC CO. (Aff. Mem.) *Walpole, Mass.* Representatives; T. J. Daley, secretary; E. O. Christiansen, treasurer; R. Everett, sales manager.

STARK, J. ROY (Aff. Rep.) electrical engineer, The Webster Electric Co., *Racine, Wis.*

THOMAS, H. M. (A) superintendent, Anderson Engineering Co., 4036 N. Rockwell St., *Chicago.*

THOMPSON, J. A. (J) chief engineer, Smith Motor Truck Corp., *Chicago.*

THOMPSON, W. H. F. (A) secretary, treasurer, manager, Enterprise Machinery Co., 1601 8th St., S. E., *Minneapolis.*

UNION GAS ENGINE CO., THE (Aff. Mem.) *Oakland, Cal.* Representative: O. H. Fischer, president, general manager.

VAN HALTEREN, ANDREW S. (M) engineer, Prudden Wheel Co., *Lansing, Mich.*

VEEDER, CURTIS H. (M) president, The Veeder Mfg. Co., *Hartford, Conn.*

WADE, GUSTAV (A) instructor, airplanes and airplane engines, Signal Corps, U. S. A., Hall-Scott Motor Car Co., *Berkeley, Cal.*, (mail) 451 28th St., *Oakland, Cal.*

WALKER, WILLIAM L. (A) in charge of government and aeronautical department, United States Rubber Co., 1790 Broadway, *New York.*

WARD, HORACE (A) president, general manager, Ward & Co., 816 14th St., N. W., *Washington.*

WARD, LOUIS M. (Aff. Rep.) secretary, The Cushman Motor Works, *Lincoln, Neb.*

WEBSTER ELECTRIC CO., THE (Aff. Mem.) *Racine, Wis.* Representatives: Walter Brown, vice-president, general manager; S. Arthur Loeb, secretary-treasurer; Arthur C. Kleckner, chief engineer; J. Roy Stark, electrical engineer; Harry Daniel Dodge, sales engineer.

WHITAKER, FREDERICK P. (A) representative, Hall-Scott Motor Car Co., Inc., 818 Crocker Bldg., *San Francisco,* (mail) 165 Broadway, *New York.*

WHITE, J. W. JR. (M) engineer, secretary, Industrial Equipment Co., 70th St. & Garfield Ave., *Oakland, Cal.*

WOTTRING, L. R. (A) chief engineer, Houghton Motor Car Co., *Marion, Ohio,* (mail) 273 Thew Ave.

Book Reviews *for* S. A. E. Members

This section of the S. A. E. JOURNAL is devoted to the technical books considered to be of interest to members of the Society. Such books will be described briefly as soon as possible after their receipt, the purpose being to show concisely the general nature of their contents and to give an estimate of their value.

TEXTBOOK OF THE MATERIALS OF ENGINEERING. By Herbert F. Moore. Published, 1917, by the McGraw-Hill Book Co., 239 West 39th St., New York. Cloth 6 by 9 in., 204 pages, 69 ill., 11 tables. Price $2.

This concise and elementary presentation of the physical properties of the common materials used in structures and machines is intended primarily as a textbook. It will also be of value to draftsmen, inspectors, machinists, engineers and others who deal with the materials of engineering. Brief descriptions of the manufacture and fabrication of materials are given. Although elementary, as a 200-page book on such a broad subject must necessarily be, the reader is aided in a broader study by a list of references at the end of each chapter. These have been selected with a view to their availability in all technical school and city libraries. A list of questions on the various chapters is given at the end of the text as an aid to teachers desiring to use the book as a text.

The general subjects covered are: Principles of stress and strain, manufacture and properties of iron and steel, heat-treatment, non-ferrous metals and alloys, timber, stone, brick, terra-cotta, cementing materials, testing, inspection and specifications, and resistance of materials to repeated stress.

The principles of stress and strain are illustrated by several diagrams for different materials showing the elastic limits, proportional limits, yield points and points of ultimate strengths. A short chapter is given to the determination of the working stress and the factor of safety. Necessary considerations are mentioned for use in selecting materials for various classes of machines or structures.

The brief descriptions given of the manufacture of pig and wrought iron and open-hearth, bessemer, cementation, crucible and electric furnace steel are simplified by instructive illustrations showing the construction and operation of the various equipments. The methods of making iron and steel castings are briefly summarized. The mechanical treatment of steel is considered, special emphasis being paid to defects and their prevention.

The crystalline structure of iron and steel is explained with its significance. It is to be regretted, however, that the tempering of steel and its heat-treatment are not given the attention they deserve even in such a short book. The effect of various elements on the properties of iron and steel are presented briefly. The properties and uses of copper, aluminum, zinc, brass and alloys are mentioned. The author's treatment of the subject of timber is excellent, due importance being given to preservative processes.

The chapter on Portland cement and concrete covers manufacture, proportioning, effect of undesirable ingredients, mixing and general properties. The chapter on testing, inspection and specifications for materials fully emphasizes the necessity of the testing engineer. Commercial testing and standards specifications are given.

An interesting chapter covers mechanical hysteresis, repeated stress tests and the effect of range and rapidity of repetition of stress. The service expected from machine parts and allowable working stresses are presented. General tables of working stresses for a number of materials have been incorporated in the book.

GOVERNMENT PUBLICATIONS

FRENCH-ENGLISH MILITARY TECHNICAL DICTIONARY. By Col. Cornelis De Witt Willcox. Published, 1917, by the Government Printing Office, Washington. Cloth, 6 by 9 in., 581 pages. Price 85c.

The need is urgent at present for some sort of an up-to-date French-English technical dictionary. The only good ones available in this country were written by Germans and published by them and it is very difficult to obtain them in any event.

In the preface the author mentions the fact that it is necessary, on account of the extremely detailed nature of technical French nomenclature, to substitute descriptions for names on account of the habit the French have of using technical phrases of extremely minute significance. This method of giving descriptions, however, is far from being a handicap, and appears to make the book of much greater interest because of the information it gives regarding French engineering.

Since the first edition of the book, the author has been collecting new terms for inclusion in a later edition. In order to make these terms immediately available, it was found necessary to publish them in a supplement in the back of the book. This contains a large number of the phrases used in the present war. It would be better, of course, if these phrases could have been inserted in the main portion of the book, but the need for such a volume is so pressing that Col. Willcox's volume will be found of great service to a large number of engineers.

PREPAREDNESS CENSUS OF MINING ENGINEERS, METALLURGISTS AND CHEMISTS. By Albert H. Fay. Published, 1917, by Government Printing Office, Washington. Paper, 6 x 9 in., 19 pages.

In the conduct of war today chemists and engineers play a far greater role than ever before. The products of the mines, furnaces, factories and chemical plants are being consumed so rapidly that the highest possible skill is required to keep pace with the destruction. In the organization of a great army, many classes of specialists are needed, and the problem is to get the best qualified men for each place. Men with a knowledge of sanitation are essential to the health of the soldiers at the various training camps. Men with an intimate knowledge of pyrotechnics find a place in the manufacture and use of certain signal devices and telephone and telegraph operators are essential for systems of rapid communication, without which valuable time may be lost. Coal and iron are absolute necessities for the manufacture of arms and munitions, and many naval vessels cannot be operated without the use of petroleum as a fuel, and motor trucks are useless without gasoline, or of spirits with greater difficulty.

(*Concluded on page 4 of the Adv. Sect.*)